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AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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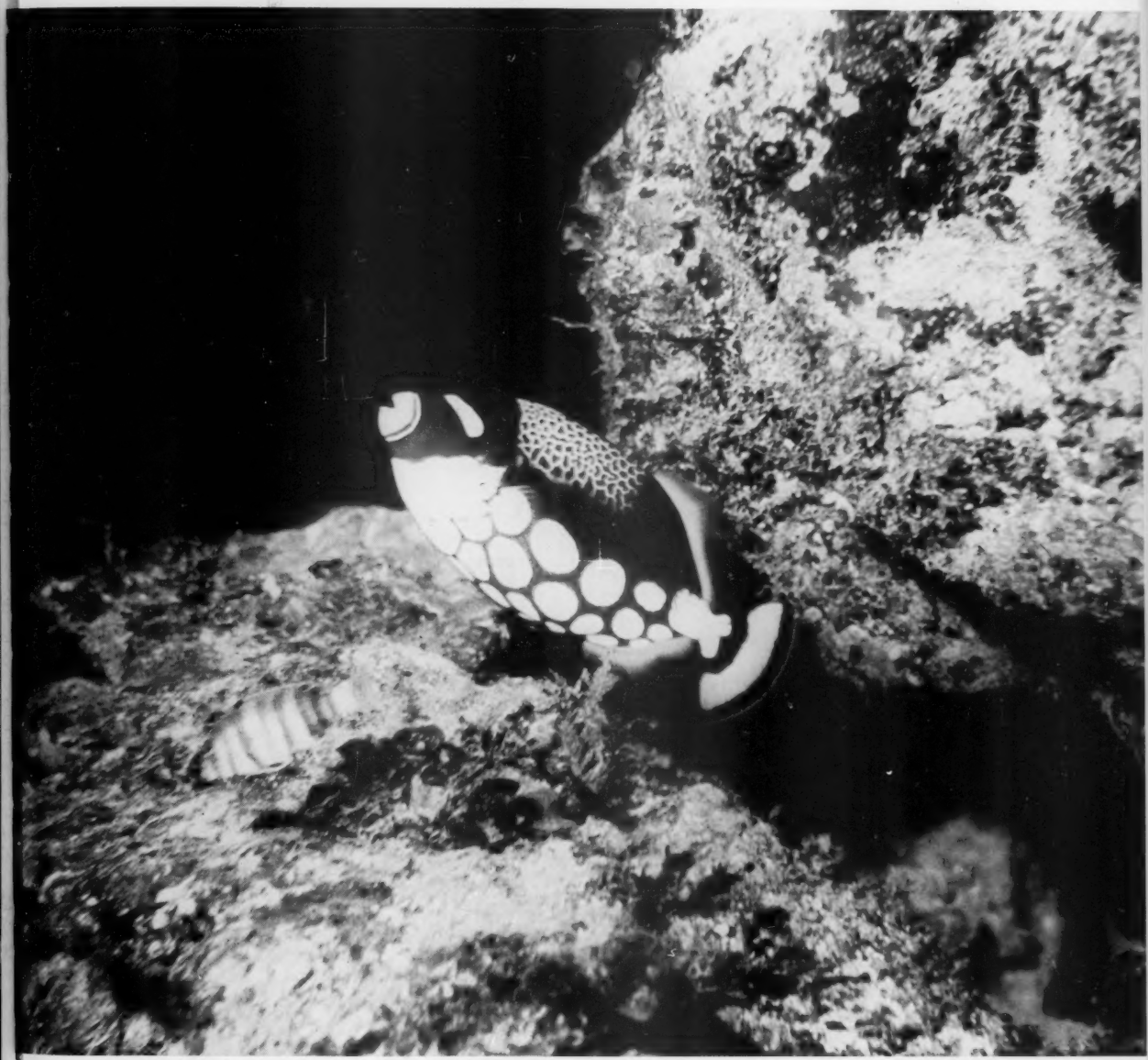

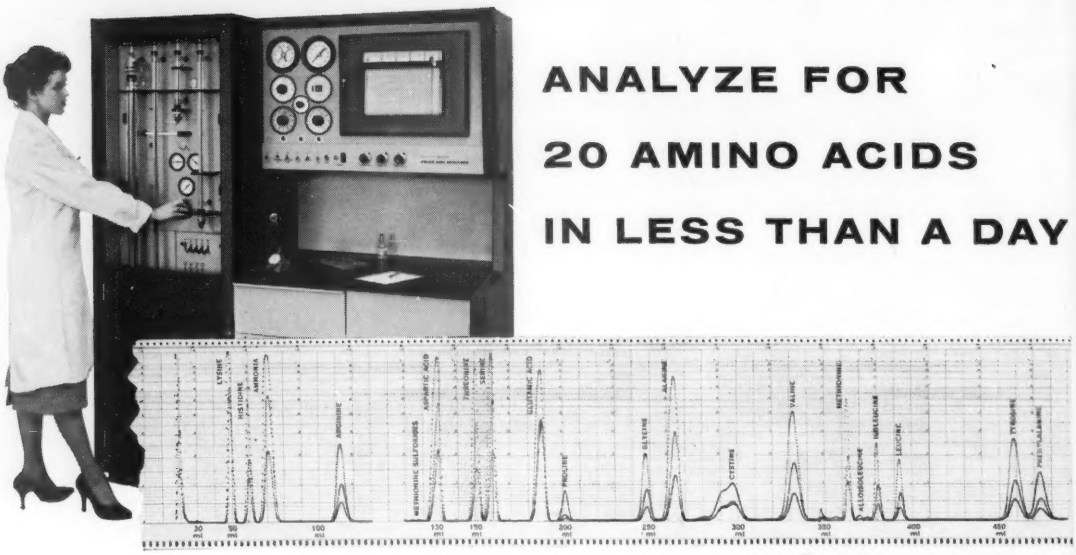

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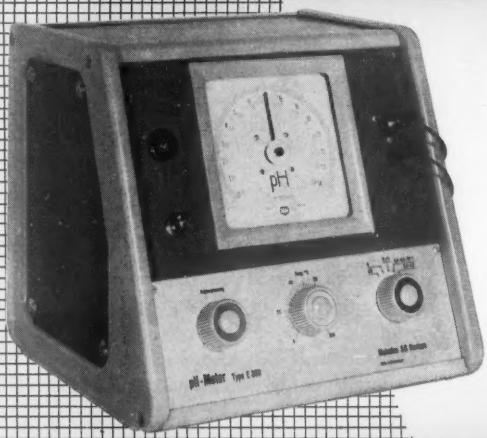

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Leopard or queen triggerfish, *Balistes conspicillum* Bloch and Schneider *(Balistoides niger)*, photographed at a depth of about 100 feet, in Okinawa. The fish spends much of its time in the seclusion of coral grottoes. [J. D. Bromhall, University of Hong Kong]

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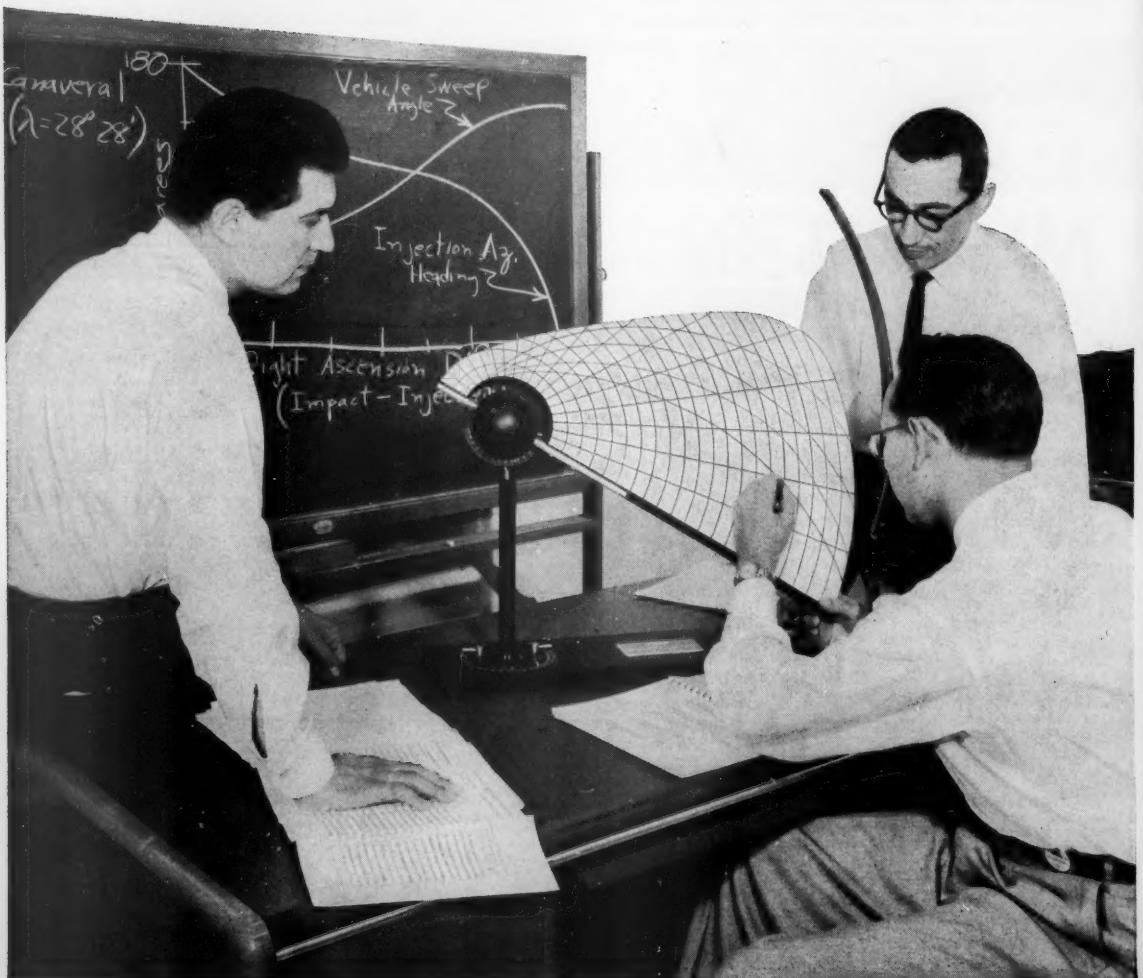

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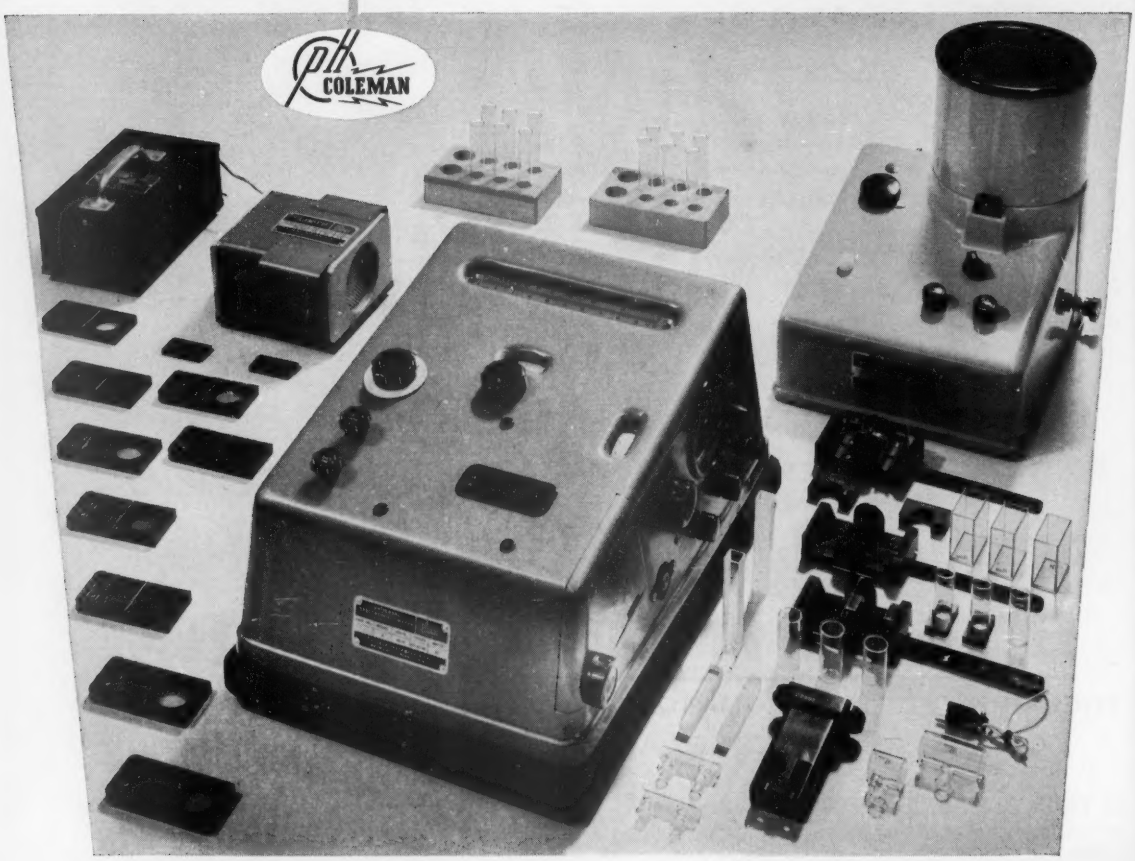

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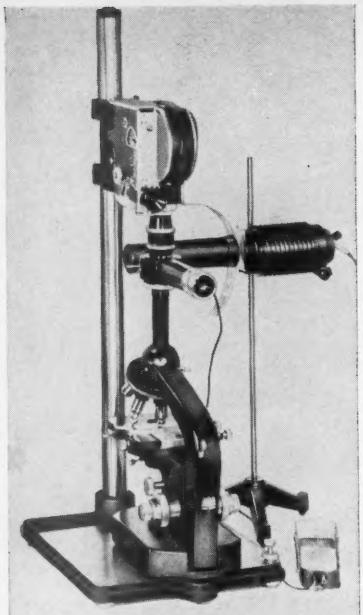

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Letters

Birth Control and Catholic Doctrine

The comments of J. K. O'Loane [*Science* **130**, 1302 (1959)] on M. E. Davis' review of Sulloway's *Birth Control and Catholic Doctrine* [*Science* **130**, 559 (1959)] deserve notice because they illustrate strikingly the dual intellectual attitude of the Catholic scientist. O'Loane is quite correct, of course, in his description of the distinction which the Catholic Church makes between its doctrine and its opinion. As a scientist he will no doubt understand that for a non-Catholic what matters is what the Church claims and does, and not whether, inside the Church, one particular claim is based on doctrine, or on personal taste, or on scientific evidence. It must have been small consolation to Bruno and Galileo that their torments were caused by the then prevalent opinion of the Church and not by a point of immutable doctrine.

As regards the important subject of controlling the size of our population, scientists are glad to learn from O'Loane that Catholic *doctrine* is not against artificial birth control; this justifies the hope that on this point also the Catholic Church will someday change its opinion, even if—as in the case of the heliocentric system—it takes three centuries to do so.

GEORGE CALINGAERT
101 Ver Planck Street,
Geneva, New York

In a recent letter J. Kenneth O'Loane reproved M. Edward Davis for accepting Sulloway's view that the Catholic Church has made an official pronouncement against contraception. O'Loane contended, *au contraire*, that although some Catholic writers have adopted the position alleged by Sulloway to be the Church's, the Church itself "never has taken a doctrinal stand that 'separation of intercourse and parenthood' is wrong." In this dispute I side with Davis and Sulloway and should like to provide the Papal text that supports their position and to comment briefly upon the issue.

In the encyclical *Casti connubii*, dated 31 December 1930, Pius XI declared the following with regard to contraception: "Since, therefore, openly departing from the uninterrupted Christian tradition, some recently have judged it possible solemnly to declare another doctrine regarding this question, *the Catholic Church*, to whom God has entrusted the teaching and defense of the integrity and purity of morals, standing erect in the midst of the moral ruin which surrounds her, in order that she may preserve the chastity of nuptial union from being defiled by this foul stain, *raises her voice in token of her divine ambassadorship and through Our mouth proclaims anew: any use whatsoever of matrimony exercised in such a way that the act is deliberately frustrated in its natural power to generate life is an offense against the law of God and of nature, and those who indulge in such are branded with the guilt of grave sin*" (italics added) (*1*). This quotation reproduces section 56 of the encyclical in it entirety. The three sections immediately preceding it should also be consulted, for they make manifest the full intensity of the Papal condemnation.

O'Loane emphasized that "the Church is considered to have taken a doctrinal stand in a matter when she has (i) made an infallible pronouncement by the head of the Church; (ii) defined by an Ecumenical Council; (iii) authoritatively proposed some creed, formula of belief, or matter of moral behavior." Although O'Loane did not so indicate by placing the word *or* between the second and third of the criteria, each of them is a sufficient condition. Clearly, the second is not applicable to the case in point. Let us, therefore, consider the first. According to the canons of the Vatican Council of 1870, the Roman Pontiff is infallible when he speaks ex cathedra—that is, when he speaks "in discharge of the office of pastor and doctor of all Christians [*sic*]" (*2*). Referring to the text quoted above and keeping in mind that the encyclical was addressed to all the faithful, one is logically entitled to conclude that Pius XI was speaking ex cathedra. Moreover, it would be difficult to deny that the portion of the text reading "the Catholic Church . . . raises her voice in token of her divine ambassadorship and through Our mouth proclaims . . ." fulfills the third of O'Loane's criteria.

Perhaps, then, neither Sulloway nor Davis is as "deficient in philosophical and theological background" as O'Loane would have us think.

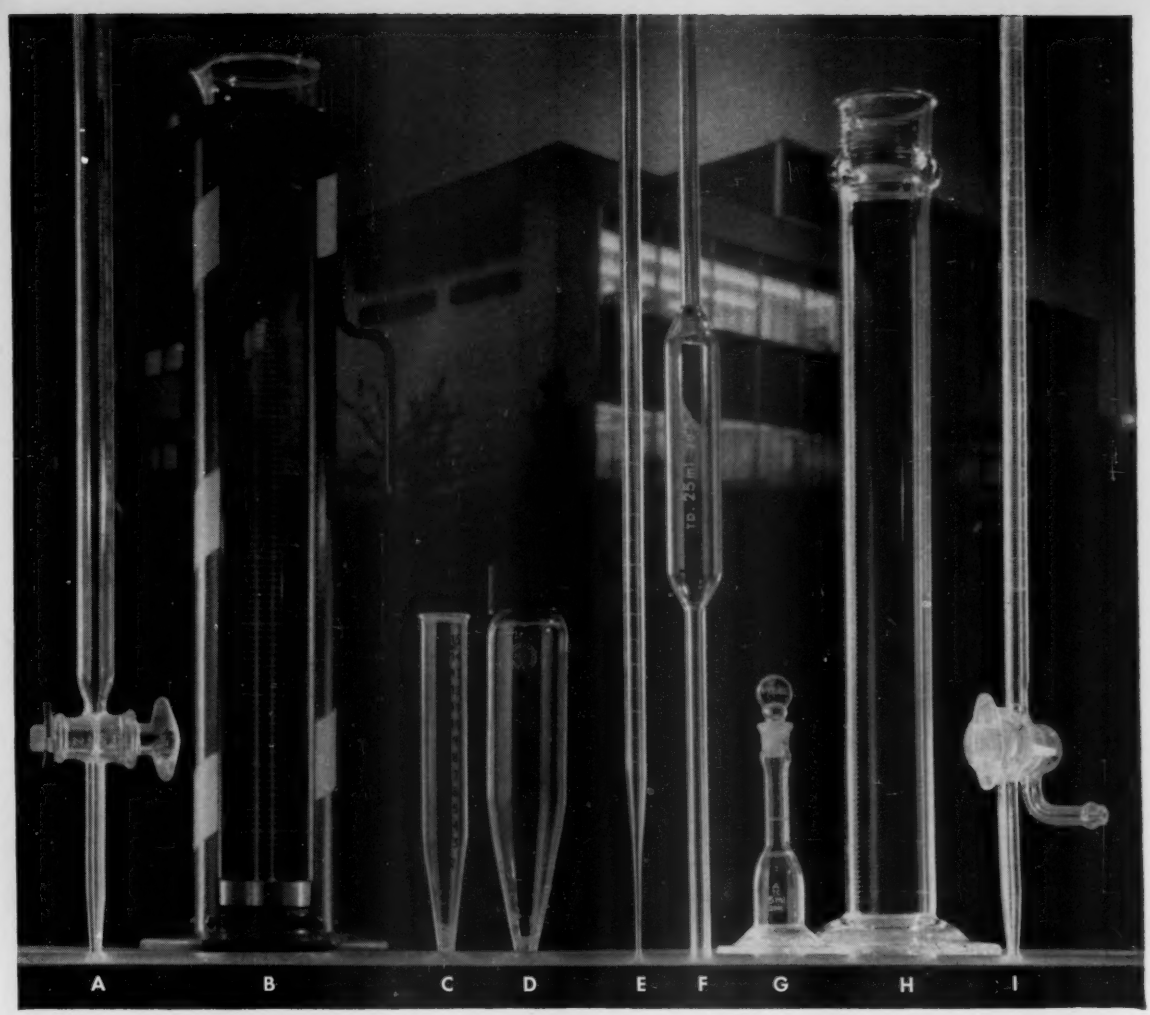
ROBERT HOFFMAN
2273 Parkhurst Road,
Elmont, New York

References

1. Pope Pius XI, "*Casti connubii*," reprinted in T. P. McLaughlin, Ed., *The Church and the Reconstruction of the Modern World* (Image Books, Garden City, N.Y., 1957), p. 136.
2. "First Dogmatic Constitution on the Church of Christ," chap. iv, reprinted in G. MacGregor, *The Vatican Revolution* (Beacon, Boston, 1957), p. 195.

In a recent issue O'Loane presents a Catholic criticism of *Science's* review of the book *Birth Control and Catholic Doctrine*. O'Loane does not like the

(Continued on page 1048)



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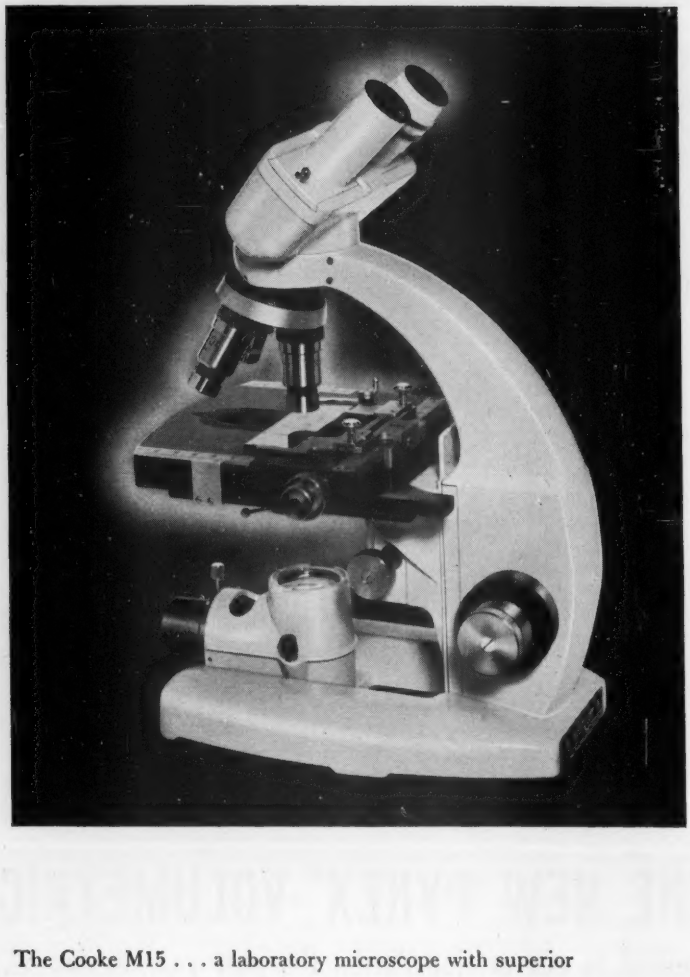

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Between Two Extremes

With science supporting an ever expanding military technology, many people in this country are wondering to what extent American scientists should assume responsibility for the uses to which the government puts their discoveries and talents. It has always been possible, of course, to speak of pure research, just as it has always been possible, we suppose, to speak of the pure act of sitting down to a meal and consuming it with impeccable table manners. But any piece of behavior can acquire moral properties, given the appropriate circumstances—even sitting down to eat a hamburger, as recent developments in the South have shown.

One view of the scientist's responsibility for the social consequences of scientific truths is that this responsibility ends with the scientist's willingness to do work directly or indirectly for the government, including work on weapons. According to this view, being a good scientist no more gives one special privileges in determining national policy than being a good information clerk at an airport entitles one to select destinations for travelers. The area of special competence of scientists lies in the discovery of technical facts; decisions of public policy rest with elected or appointed public officials.

An opposite opinion concerning the obligations of scientists holds that scientists should consider the possible consequences of any piece of research before it is begun, and if the research is judged more a threat to the country, or humanity at large, than a benefit, they should refuse their services. A man cannot delegate to a superior the responsibility for the moral consequences of his acts, the second view claims. To be sure, to predict future applications of new discoveries calls more for the talents of a prophet than for those of a scientist. No one now knows to what uses, or abuses, the fall of parity in physics may some day prove amenable. But somewhere along the line, basic research becomes applied research, and forecasts about the uses of discoveries become something more than anybody's guess.

Between the two opposing positions lies a third position which holds that at least some scientists, although they fear the dangers posed by a further increase in military power, have the duty to work on projects that the government deems necessary, but that scientists also have the duty to state their opinions on matters lying outside science. If this is the age of specialization, so this argument runs, it is also the age of specialists working together on teams. Public officials should have the final word, but any attempt to understand the full range of consequences—military, political, economic, and moral —of new advances in research, requires the views of the men who understand those advances best.

It is this third position that expresses our own convictions, and that seems to express the convictions of most of the persons in this country who are presently concerned with these problems—although, admittedly, agreement on general principles does not necessarily imply agreement on particular cases. The first position errs because, pushed to its conclusion, it turns the citizen's obligations to the state into despotism; while the second position errs because, if pushed, it turns the moral integrity of the individual into anarchy. The third position seeks the mean between the scientist's assuming too little responsibility for the consequences of his research and his assuming too much responsibility.—J.T.

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CURRENT PROBLEMS IN RESEARCH

Movement of Radiostrontium in Soils

Knowledge of climatic and soil factors is important in determining the redistribution of strontium fallout.

C. W. Thornthwaite, J. R. Mather, J. K. Nakamura

The presence of radioactive strontium-90 in the atmosphere and in the soil and waters of the earth is one of the most compelling facts faced by our present generation. Injected into the atmosphere through the testing of nuclear weapons, dispersed to all parts of the globe through the latitudinal movement of air, and returned to our earth mainly by precipitation, strontium-90 is one of the most hazardous of all of the radioactive isotopes because of its long half-life and its similarity to calcium as a bone seeker in the human body. Probably the greatest danger from this radioisotope results from our own lack of information concerning how it reacts in the soil and waters of the earth, and in the food cycle, what the maximum permissible tolerance levels are, and what remedial measures may be taken to prevent the accumulation of dangerous concentrations in soil, air, plants, animals, and human beings. As part of a general effort to learn more about radioactive strontium, the Laboratory of Climatology in Centerton, New Jersey, has begun a long-term research study, supported by the United States Air Force, relating to the redistribution of strontium in the surface layers in the soil (*1*).

Water plays a key role in the continuing relationship between strontium-90 and man, and thus it is through an understanding of the influence of water on the redistribution of strontium that we can begin to determine the nature of this relationship. There are two main ways in which water influences the movement of strontium; precipitation is the principal agent in the removal of strontium from the atmosphere, and the gravitational or surplus water in the soil is the principal agent in the redistribution of strontium with depth in the soil. While the first of these influences is of importance in determining the geographic pattern of fallout, its study is beyond the scope of the present article. This article serves, rather, to sum up some of the results of our work on the second part of the water-strontium problem. Because of our own special study of the moisture factor in climate, our approach to the problem has been through determination of the quantity and seasonal distribution of water surplus at a given place by the climatic water-balance bookkeeping technique presented by Thornthwaite in 1948 (*2*) and revised by Thornthwaite and Mather in 1955 (*3*).

Climatic Water Balance

The relative moistness or aridity of a given place can be determined from a comparison of the moisture supply (the precipitation) with the climatic need for water (the potential evapotranspiration). Potential evapotranspiration is the water flux into the atmosphere from a vegetation-covered surface whose soil is supplied at all times with sufficient moisture for all the needs of the vegetation. When precipitation exactly corresponds to the climatic need for water there is no moisture surplus or deficiency and the climate is neither moist nor dry. Such correspondence between precipitation and potential evapotranspiration occurs only infrequently in nature and then only for short periods of time. Normally, the precipitation is either greater or less than the need for water. When the precipitation is greater than the need for water and the soil is at its water-holding capacity, there will be a water surplus equal to the excess of precipitation over the water need. When water need exceeds precipitation, there is a water deficit which equals the unfulfilled moisture requirement of the vegetation—that part not supplied by precipitation or supplied from storage of moisture in the soil. The water surplus and water deficit at any time and place can be determined from a simple water-balance bookkeeping procedure. These elements of the water balance and their timing are basic factors in pedogenesis. The water surplus moves mainly downward through the soil and is the leaching solution. Thus, it is the water surplus which is responsible for the redistribution of strontium in the soil.

Mathematical Model of Strontium Movement

A number of investigators (*4*, *5*) have made actual physical measurements of the rate of movement of strontium and other radioisotopes through soils. The recent report by Miller and Reitemeier (*4*) provides a great wealth of new material on the problem of movement of strontium in soil. The authors, working with tubes of soil in a laboratory, used five different types of soils (Norfolk fine sandy loam, Hagerstown silt loam, Miami silt loam, Fort Collins silt loam, and Huntley clay loam), three different types of leaching

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solution (0.005*N* $CaCl_2$, 0.005*N* NaCl, and deionized water), and two rates of application (30 inches and 300 inches) in an effort to determine the movement of strontium-89. The source of the radioactivity was a ½-inch layer (70 grams) of soil spiked with 5 microcuries of strontium-89. This soil was placed in a layer on top of 5-inch columns of the soil in tubes and covered by another ½-inch layer of uncontaminated soil. The results showed clearly that some downward movement of strontium occurred and that there were differences from soil to soil. For a given amount of leach water added to the surface of the soil in the tubes, there was a greater amount of movement of strontium in the sandy soil than in the silt loams and the clay loam. This result was to be expected on the basis of the ion-exchange capacities of the different soils.

The experiments of Miller and Reitemeier and others show that there is an organized movement of strontium in the soil responding to the various soil and water factors in such a way that a certain percentage of the original concentration of strontium moves downward to the next lower layer in the soil with every unit of water added. The amount of the downward movement depends on the cation-exchange capacity and *p*H of the soil and the leaching efficiency of the water solution.

In order to describe the measured distributions found by Miller and Reitemeier, a mathematical model was set up. Paralleling the experimental procedure, the soil was divided into ½-inch layers or zones, and the strontium concentrated in the first or source layer was followed downward to the ½-inch zones below. The movement of strontium was conveniently divided into cycles, each cycle being complete when one-tenth of the strontium in each zone had moved downward to the next zone. Other fractions could have been used just as well. A cycle is completed when the selected percentage of the distribution of strontium has moved downward from each zone into the next lower zone.

Expressed mathematically, with an initial concentration X_0, the concentration of material with depth in the soil after t complete cycles of movement is:

$$X_n = \frac{t!}{(t-n)!\,n!}\, k^n(1-k)^{(t-n)}\, X_0$$

where X_n is the concentration in the nth layer, n is the receiving layer, t is the cycle of leaching, k is the fractional loss per cycle, and X_0 is the initial concentration of strontium-90.

The concentration in the source layer after t cycles of leaching (X_{n_0}) is expressed simply as

$$X_{n_0} = (1-k)^t\, X_0.$$

The number of cycles required for X_n to reach a maximum in the nth layer is given by

$$t = n/k.$$

There is a definite maximum concentration of the quantity X_n in any given layer. This value is reached when the amount of movement downward out of the given layer just equals the amount received from overlaying layers.

In their recent paper Miller and Reitemeier measured the concentration of strontium with depth after leaching of different soils with three different leaching solutions—deionized water, 0.005*N* sodium chloride, and 0.005*N* calcium chloride. The results for four soils leached with 0.005*N* calcium chloride are given in Fig. 1. The vertical distributions (in percentages) of an initial concentration of strontium, computed by use of the above equation, are also shown in Fig. 1. The number of leaching cycles, the quantity of water applied, and the ratio between these two quantities are given in Fig. 1. As can be seen, there is close agreement between the measured distribution of strontium with depth and the calculated distribution. In the four examples in Fig. 1, the soil type, the cation-exchange capacity of the soil, and the amount of water used for leaching differed. Similar comparisons were made of the results for the four soils after leaching with deionized water and 0.005*N* sodium chloride. Without exception there was good agreement between the distribution given by the mathematical model and that actually found by Miller and Reitemeier.

The mathematical model has, in effect, established particular leaching pat-

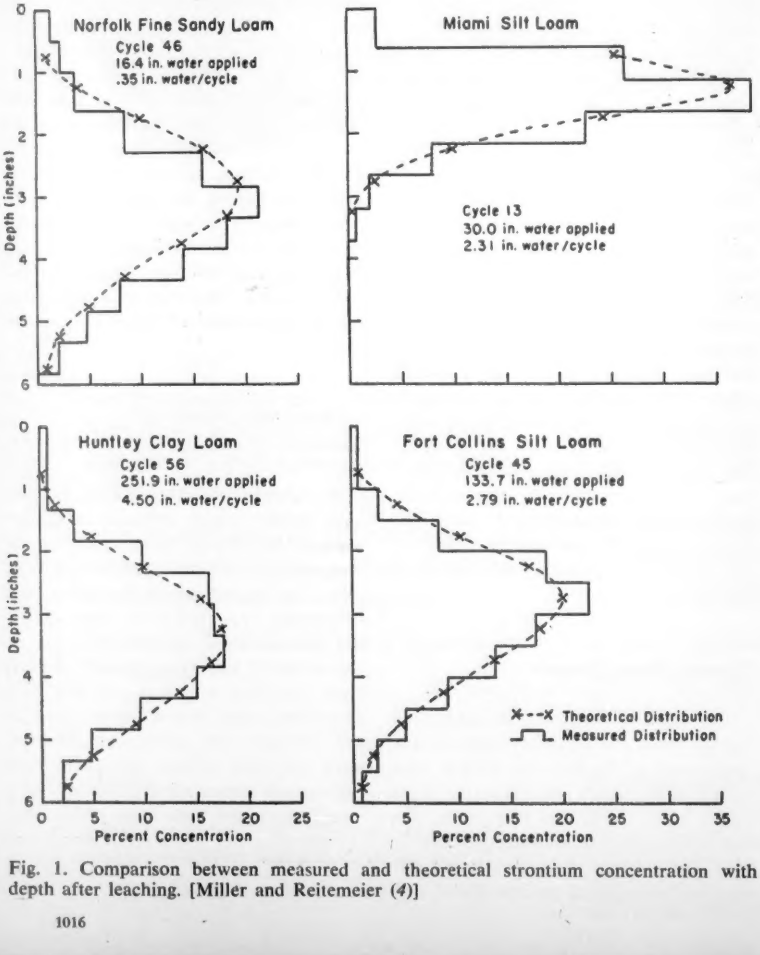

Fig. 1. Comparison between measured and theoretical strontium concentration with depth after leaching. [Miller and Reitemeier (*4*)]

terns for the various solutions. The time necessary for the establishment of such a pattern for the solutions used is dependent upon the following factors: (i) the cation-exchange capacity (CEC) of the soil; (ii) the *p*H of the soil; (iii) the leaching efficiency of the solution; and (iv) the volume of the leaching solution applied.

The general relation showing the influence of the cation-exchange capacity and the *p*H of the soil on the leaching efficiency of the solution is given in the equation

$$L = L_1 \left(\frac{7.0}{pH}\right)^{-b} C^{-a},$$

in which L is the leaching efficiency in cycles per unit of applied water; L_1 is the leaching efficiency at unit cation-exchange capacity (at *p*H 7.0); C is the cation-exchange capacity in milliequivalents per 100 grams; a is the exponential cation-exchange capacity correction factor; and b is the exponential *p*H correction factor.

Since

$$L = t/P,$$

where t is the number of cycles of leaching and P is the amount of water applied, then

$$t = PL_1 \left(\frac{7.0}{pH}\right)^{-b} C^{-a}$$

The following is a summary of the values of the elements in the above equations.

	L_1	a	b
$CaCl_2$	11.3	1.128	0
NaCl	0.13	0.35	0
H_2O	0.124	0.53	1.6

The results are shown in Fig. 2. Since the *p*H of the soil exerts no measurable influence on the leaching efficiency of calcium chloride and sodium chloride solutions, the graph merely shows the relation between leaching efficiency and cation-exchange capacity. The rather large effect of *p*H on the leaching efficiency of water is indicated by a displacement of the observed points on the graph, shown by the arrows. A comparison of the measured and computed values of leaching efficiency is given in Table 1.

The curves for calcium chloride and sodium chloride intersect at a cation-exchange capacity of approximately 300. It is entirely reasonable to assume that for equivalent concentrations of the various chlorides found between Na^+ and Ca^{++} in the activity series, proportional curves could be drawn between the two shown, with the value of cation-exchange capacity of 300 the focus of the chloride curves. It is also not unreasonable to theorize that the same cations with another anion, for example SO_4^{--} or OH^-, would intersect at another specific cation-exchange capacity.

Applicability to Natural Soils

The mathematical model of movement downward through the soil represents the distribution of strontium in a column of soil in the laboratory. This does not answer the practical question of whether the model will also represent the distribution with depth and time of strontium in different natural soils *in situ* after leaching with natural rain water. Because of the influence of factors of the natural environment—the presence of a natural vegetation cover and the resulting uptake of strontium, the alternate wetting and drying of natural soils due to variable daily weather conditions, the presence of earthworms, the occurrence of natural weathering, and the chemical composition of natural precipitation—it is important to test the mathematical model against actual field measurements of strontium concentration with depth.

The Health and Safety Laboratory of the New York Operations Office of the Atomic Energy Commission has undertaken a soil-sampling program in an effort to determine the amount of fallout which occurs (*6*). In addition, it has measured monthly and daily fallout by means of pot and gummed-film collectors. While these data are not sufficient to provide a complete understanding of the movement of strontium with depth, they do provide a rough check on the applicability of the mathematical model.

The distribution of strontium in the soil in New York City as determined by soil sampling for the period 1955 through 1958 was compared with the computed values. The results are summarized in Table 2.

The observed values for strontium were obtained by radiochemical analysis of soil samples taken at La Guardia Airport in October of 1955, 1956, and 1957 and in Central Park in 1958, while the computed values were obtained from

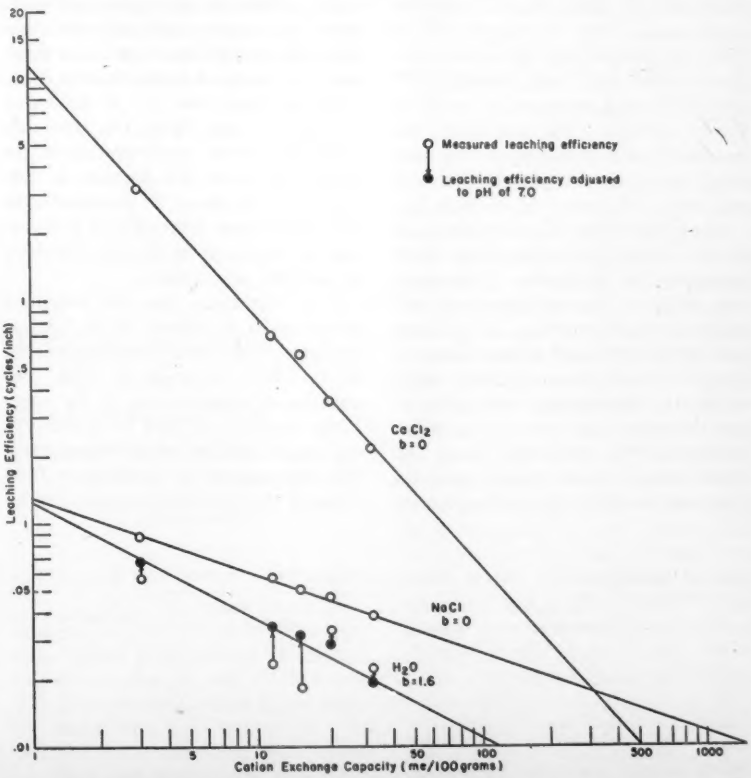

Fig. 2. Relation between various solutions and cation-exchange capacity.

Table 1. Comparison of the measured and computed values of leaching efficiency for the three leaching solutions.

Soil	pH	CEC (meq/100 gm)	H_2O L (cycle/in.)		NaCl L (cycle/in.)		$CaCl_2$ L (cycle/in.)	
			Meas.	Comp.	Meas.	Comp.	Meas.	Comp.
Norfolk	6.3	3.0	0.057	0.058	0.087	0.088	3.125	3.271
Hagerstown	5.5	11.5	.023	.023	.057	.055	0.690	0.718
Miami	5.0	15.7	.018	.017	.050	.050	.568	.505
Fort Collins	7.7	20.1	.033	.029	.047	.047	.351	.382
Huntley	7.8	32.6	.023	.023	.038	.038	.213	.222

Table 2. Observed and computed distributions of strontium-90 in the soil in New York City (in millicuries per square mile).

Soil depth (in.)	1955		1956		1957		1958	
	Obs.	Comp.	Obs.	Comp.	Obs.	Comp.	Obs.	Comp.
0 to 2	5.75	8.63	11.15	12.35	18.92	16.29	16.25	15.43
2 to 6			13.00	11.75	7.33	14.14		
2 to 9							20.30	27.68
6 to 12					7.60	10.72		
Below 9								15.24
Below 12						2.97		
Total	5.75	8.63	24.15	24.10	33.85	44.12	36.55	58.35

the monthly values of fallout by applying the mathematical model. In these computations, a leaching efficiency of five cycles of leaching for each 100 millimeters of water was found to apply for movement in the top 2-inch layer, while a leaching efficiency of one cycle for each 12 millimeters of surplus water worked well on the soil layers below 2 inches. For the period 1952 to 1954 the fallout was estimated from gummed-film data, and between 1954 and 1957 it was measured by means of a pot collector. The estimated and measured values of fallout and the computed values of water surplus for each year since 1952 are given in Table 3.

Many difficulties are encountered in trying to utilize the mathematical model to compute the distribution of strontium with depth in the soil: Measured soil values of strontium content do not agree well with accumulated values of fallout, there are errors in radiochemical analyses of the soil samples, and soil samples themselves are not always representative of the local area. These and other sources of error exist and can contribute to a lack of close agreement between the measured and the computed values of distribution with depth. An error in sampling or analysis is seen in the value for observed strontium concentration in the 2-to-6-inch layer in New York City (Table 2). While the concentration in the 0- to 2-inch layer increases from 5.75 to 11.15 and then to 18.92 millicuries per square mile, the value for strontium concentration in the layer below goes up from 0 (unmeasured but assumed to be close to 0) to 13.00 and then down to 7.33 millicuries per square mile. With the continued rapid rise in the concentration in the 0-to-2-inch layer, the decrease in concentration of almost 50 percent in the 2-to-6-inch layer from 1956 to 1957 can only be explained on the basis of error in sampling or analysis.

It is significant that the measured strontium-90 detention in the surface layer, which had been increasing steadily up to 1957, decreased in 1958. The leaching of strontium out of the upper 2-inch layer of soil must have exceeded the annual total of fallout during 1958. The large amount of leaching in 1958 is closely tied to the fluctuations in water surplus during the past 3 years, given in Table 3. Because of the weather in 1956 and 1957, with comparatively little water surplus available in 1957, the downward movement of strontium was reduced, and there was a somewhat greater detention in the upper 2 inches of the soil. Thus, in 1958, when a larger water surplus occurred, the rate of the flux increased markedly because of the increased supply of water for leaching and the already existing large detention of strontium in the upper soil layers.

Of the two main factors which influence the movement of strontium-90 through the soil, the cation-exchange capacity and the water surplus, it is clear that the water surplus is by far the more variable quantity from month to month and from season to season. Thus, on a long-term basis, the water surplus is the principal agent affecting the flux or the detention of strontium in the soil at a given place.

The annual water surplus (Table 3) shows considerable variation from 1952 to 1958. The number of leaching cycles corresponding to the water surplus varies correspondingly from year to year. The year 1955, for instance, had almost twice as many leaching cycles as the year 1956. The year 1958 had half again as many cycles as 1957. Because of the importance of leaching cycles in the movement of strontium, it is easier to think of the influence of the climate of a year in terms of leaching cycles than in terms of precipitation, water surplus, or other more common climatic parameters.

Table 3. Strontium fallout, water surplus, and leaching cycles in New York City, 1952–58.

Year	Estimated (*E*) and measured (*M*) fallout (mc/mi²)	Computed water surplus (mm)	Leaching cycles (0 to 2 in.)
1952	1.91 *E*	612	31
1953	3.54 *E*	924	46
1954	6.56 *E*	637	32
1955	9.22 *M*	955	48
1956	10.92 *M*	589	27
1957	11.97 *M*	556	28
1958	14.26 *M*	797	40

Summary and Conclusions

From the results of laboratory experiments it was possible to develop a mathematical model of movement in the soil which showed that a certain percentage of the strontium moved downward to the next lower layer of the soil for each unit volume of surplus water which is added to the layer. The model was verified by laboratory experiments and by actual field observations of strontium content in the soil.

During the development of the mathematical model it became clear that a number of factors would be important in any attempt to apply the model to variable field conditions. Among these factors are (i) the cation-exchange capacity of the soil both areally and with depth; (ii) the quantity of surplus water available for leaching; (iii) the initial concentration of strontium in the

soil and the increments to the soil due to fallout; (iv) the chemical composition of the rain water and the soil solution; and (v) the leaching efficiency of various solutions containing cations and anions.

Before the mathematical model can actually be applied to the problem of determining the distribution of strontium with depth at a given place, precise information on these factors is needed. While information on the water surplus at any time or place is relatively easy to obtain from the climatic water balance, and information on fallout is available from those stations at which pot collectors are being operated, and in highly generalized form elsewhere, information on some of the other quantities is not as readily available. For instance, even though soil samples are taken by the Health and Safety Laboratory of the New York Operations Office of the AEC at 17 different places in the United States, these are limited to one sample a year at a site and generally to only two layers (0 to 2 inches and 2 to 9 inches) in the soil. We do not know much about the seasonal or monthly variation in soil concentration of strontium or in its real variation with depth.

Information on the cation-exchange capacity of many different soils is available in the literature, but these data have never been assembled in a map, while information on the variation of cation-exchange capacity with depth is not at all readily available. Detailed information on the chemical composition of rain water and of soil solutions is practically nonexistent.

The future course of this study and its possible practical application will depend on the course of world events in the next several years. If weapon testing should be discontinued, either through international agreement or through unilateral decision, and if no further strontium-90 burden is added to the present stratospheric reservoir, fallout will soon reach very small levels and contamination of the soil will end. The strontium-90 in the soil will then serve as a tracer which will be of unparalleled value in studies of leaching, soil development, and ground-water hydrology.

If weapon testing should be resumed, or if a nuclear war should break out and soils all over the earth should be seriously contaminated, the natural processes of soil purification through leaching would proceed at different rates in different areas. After only a few years some soils would be decontaminated to a point where they would produce food suitable for human consumption. Soils in other areas would remain contaminated for many years and presumably would have to remain under quarantine. New sets of land values would develop, and a wholesale redistribution of any remaining population would occur. As the work begun under this research study continues, it will yield a body of principles which will apply regardless of the direction of future events.

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1. This research was supported in whole or in part by the U.S. Air Force under contract No. AF49(638)-409, monitored by the Air Force Office of Scientific Research of the Air Research and Development Command. A more complete treatment of certain sections of the study will be found in C. W. Thornthwaite and J. R. Mather, "Investigations of the climatic and hydrologic factors affecting the redistribution of strontium-90 in the soil," in *Publications in Climatology* (Laboratory of Climatology, Centerton, N.J., 1959), vol. 12, No. 2, pp. 49–91.
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Science and Foreign Affairs

Recent scientific and technical advances have had a dramatic effect on international relations.

G. B. Kistiakowsky

My theme is the impact of science and technology on foreign policy. Let me try to single out, if I can, what I believe to be the important aspects of this relation between science and world affairs.

I need not devote much space here to demonstrating the proposition that the advances of science gradually, sometimes suddenly, are altering the relations between nations and peoples. Of course, it is the technology which is the carrier of change, but it is basic science, the acquisition of knowledge, that constitutes the seed from which man makes technology grow. The advances of science, in this sense, made our political isolation from the rest of the world impossible after World War II, just as they earlier made economic isolation impossible. In military affairs, perhaps, were visible the most dramatic and fast-moving changes, as technological developments took us from TNT to H-bombs, from artillery to bombers to ballistic missiles, from cavalry patrols to early-warning radar—all changes that tended to shrink the world and increase the mutual dependence and vulnerability of nations. If, for a moment, I may revert to the language of my chemist days, humanity but a century ago was in the condition of a steady-state reaction, whereas now it is in the midst of a nonsteady, branching, chain process and science is the chain carrier. Public policy, whether domestic or foreign,

The author is Special Assistant to the President for Science and Technology. This article is adapted from an address delivered before the American Physical Society and the American Association of Physics Teachers in New York City, 29 January 1960.

must recognize this transformation, cope with the problems it generates, and use it as appropriate for the goals of our society.

The need to adjust public policy to changing human conditions, of course, is not new. What is new today is the rapidity with which the developments of science are altering the human conditions, the rapidity with which policy, particularly foreign policy, must adjust to the changes being wrought by the pace of scientific advance. Not only must it adjust; policy must prepare for, must predict, the impact of scientific discovery and must also in some sense attempt to guide it.

I return to this below. Let me explore now some other aspects of the relation of science to foreign affairs that are, I think, unique to our age (at least their importance is unique) and that provide us with our greatest immediate opportunities, and some of our major problems. I am thinking here of several things: (i) the unparalleled and in many ways unexpected political importance to a nation of having the appearance of world scientific leadership (I use the word *appearance* advisedly); (ii) the effect international scientific activities have, and can have, on the relations between states; (iii) the importance of the technical component of some prospective arms-control measures; and (iv) the relation of science to technical aid for less-developed countries. Each of these is worth careful consideration, for they are not always understood and yet they must be understood if the government and the scientific community are to fulfill the obligations and opportunities ahead of us in these areas.

Scientific Leadership

First, that matter of scientific leadership and its political impact. Scientific and technological progress has acquired status as the symbol of strength because of its obvious relation to military power, as well as to productivity and the good life. This is in evidence within our borders and everywhere beyond. The striving to emulate American scientific and technological progress has become an ambitious and urgent goal for countless millions of people, including, I might note, the Soviet Union.

But unfortunately it is the technological spectaculars which the public at large and, often, the press, tend to use as the sole measure of scientific as well as technological prowess, and thus, of military power as well. Achievements in outer-space activities are, of course, the prime example of this. Perhaps a few comments about our space and missile program in this light are in order.

An intercontinental ballistic missile capability is not necessarily dependent on huge rocket booster vehicles capable of sending multi-ton payloads into space. By the general public, in this country and certainly abroad, this is not well understood. The Soviet Union, of course, has not been lax in attempting to confuse the issue. Our development of long-range rockets began late because our military planning was founded on air-breathing engines. To move ahead as rapidly as possible in ballistic missiles, we chose—and wisely I believe—to make our missiles as compact as possible to deliver warheads of adequate yield. We could do this with an ICBM with a thrust only one-half that of the Soviet ICBM's because of our advanced nuclear weapons technology.

In this we have been successful; first the IRBM's and then the Atlas missile were perfected and became operational. But as a result of our planning and preoccupation with smaller missiles adequate to do the military job required, the rocket vehicles we developed did not have sufficient thrust to send spectacular payloads into space. We did not begin work on large rocket boosters until it was too late to match past Russian performance in outer space. But, it is important to remember that the extra-large rockets are not required for our long-range missiles; hence, our deficiency in outer-space payload capability does not indicate an inferior military capability.

Another important fact must be kept in mind. That is that our scientific studies of outer space, accomplished with smaller rocket boosters, have enjoyed unprecedented success. Our scientific achievements in space have easily matched those of the Soviet Union, nothwithstanding the greater publicity given the Soviet technological spectaculars. This, I believe, is generally recognized by the world's scientific community. In addition, we are now making rapid progress toward practical applications in "near-outer space" for the benefit of all nations and peoples.

I do not suggest that we accept a secondary role in future outer-space activities requiring large rocket boosters. We cannot ignore the very real political implications of various spectacular accomplishments in outer space that have come to have symbolic meaning to the world at large. We are indeed moving ahead rapidly to develop boosters for space-exploration missions requiring very large payloads and are vigorously pursuing the man-in-space program. But we must accept the technical reality that, despite a vigorous national effort to develop such boosters, there are limits to the speed with which the gap can be closed, and these limits are largely set by technological factors. Meanwhile there are for us major opportunities to carry out sound and exciting programs in space science and technology that will redound to our national benefit in terms of enhanced prestige and welfare. For example, the development of meteorological satellites could prove to be of great benefit to all nations and could substantially contribute to our scientific and technological stature throughout the world.

To repeat, we cannot accept a secondary role in future outer-space exploration. But true leadership must be seen in the context of far broader efforts. We must be constantly aware that our strength lies in excellence spread over a wide scientific and technological base. It is a feature of an authoritarian form of society that its government can concentrate efforts in narrow fields. If the total strength of such a society is substantial, as is that of the Soviet Union, then what one might term temporary technological superiority can be achieved by that society in selected directions. So long as this superiority is temporary, so long as it does not permit a vital military advantage, and so long as it is not across a broad front, there is no need for alarm, but we must increase our efforts to cancel out imbalances that arise and are significant. On the other hand, we must not permit ourselves to be stampeded into overemphasizing one area at the expense of others. We must constantly bear in mind the sound military doctrine that the enemy should not be engaged on a field of his choosing. Rather, we must continue to move across the entire broad front of scientific and technological advance. Thus, as a nation, we will remain a world leader.

Scientific Activities and Relations between Nations

Let me turn to the second aspect of the relation of science and foreign affairs on my list—the significance of

international scientific activities to the relations between nations. Here I think is perhaps the most important of the roles science and scientists can play in today's embittered and divided world—not a new role in the sense that international activities of science are part of the lifeblood of science, but new in its potential impact on political relations.

For science is today one of the few common languages of mankind; it can provide a basis for understanding and communication of ideas between people that is independent of political boundaries and of ideologies. For example, eventually these personal relationships, established with Soviet scientists who form a major portion of Russia's intellectual elite, can provide a bridge between our cultures and assist in bringing about an evolution of the militant aspects of Communist ideology.

Science also provides a sometimes unique opportunity for cooperative endeavors that can contribute in a major way to the reduction of tension between nations and, more positively, to close relations between the United States and other countries—all this, of course, in addition to offering a means of cooperative attack on problems of interest to all nations.

This has been recognized many times before, and I can point to many activities of the government and of private scientific bodies that further these goals: normal international scientific union activity, the IGY, the exchange agreement between the national academies of sciences of the United States and the U.S.S.R., the very recent McCone-Emelyanov agreement, the UN Atoms for Peace conferences, and many, many others. However, the question must be asked whether we are doing enough in this area, and particularly whether the government is sufficiently active in instituting projects of its own, in supporting nongovernmental activities, and in creating and maintaining the necessary conditions for effective international scientific activity. What are some of the issues that face the government in this area?

The most obvious is how to balance the resources for international scientific projects against domestic scientific needs and should the federal government be doing more itself internationally, or should it support private efforts only? In either case, can you justify support for international projects when there are good scientific projects in this country that lack adequate support? A good illustration of this problem is presented by the scientific program in Antarctica. The government had to face the question of setting the level of antarctic activity in the knowledge that supplying funds for that program would detract in some measure from the support of deserving programs within the United States. There are few guidelines for determining the appropriate level of scientific activity in Antarctica, just as there are few guidelines for determining the appropriate level of activity in specific scientific fields.

In fact, the problem of Antarctica is not dissimilar from that of outer space (except that we now have a treaty reserving Antarctica for scientific research). Political considerations are important in setting this program level also. These considerations relate to the stature and scope of our effort relative to that of other countries, particularly the U.S.S.R., and, in the past, in Antarctica, to the relation of research to possible territorial claims. And so, the antarctic program is set as an orderly, sound, scientific effort, but with political awareness that the scope and excellence of the U.S. effort there has more than scientific significance.

The question of appropriate means for carrying out international activities comes up time and again. Can these be handled through the scientific community, in the way the IGY was planned and organized by the ICSU? What is the appropriate role for the UN, for UNESCO, for NATO? Should it be a government-to-government project because of the resources required? And if so, are bilateral or multilateral arrangements to be preferred?

A recent example may be illustrative, if I may be pardoned for referring to space science once again. When the UN Outer Space Committee was established, the suggestion was made that the committee itself should be responsible for conducting outer-space research, or at least for planning research on an international scale. Notwithstanding our strong desire for international cooperation in space, this was thought to be clearly inappropriate. Because of the large resources required to provide boosters for space exploration, it was considered necessary to keep the final decisions regarding space flights in the government's hands. On the other hand, international scientific planning and cooperation was clearly desirable at the scientist level, without the complex governmental machinery of the UN, which would inevitably have to face political issues. Therefore, the UN committee will be concerned with the mutual exchange and distribution of information, the study of legal problems of outer-space, the conference on outer-space exploration, and the general encouragement of space science. The National Aeronautics and Space Administration will make formal agreements with foreign governments for scientific cooperation, but both the UN and NASA will look to the Committee on Space Research of ICSU for the scientific cooperation and planning necessary to bring about effective international scientific collaboration.

The issue of bilateral versus multilateral agreements is one that is also of much interest at the present time, in view of the recent U.S.–U.S.S.R. agreement on peaceful uses of atomic energy. Notwithstanding the very real gains we may achieve through increased contacts with the Soviet Union, we must avoid any series of moves that would create a U.S.–U.S.S.R. scientific axis. Thus, it was carefully stated in the agreement with the U.S.S.R. that any joint projects would be carried out under the aegis of the International Atomic Energy Agency, where all member countries could participate. Clearly, what may be now the finest high-energy physics facility in the world—the European Organization for Nuclear Research (CERN)—should be included in activities under the agreement.

A receptive climate for international scientific activities requires government action too, or in some cases, lack of government action (in a positive sense). Science must not be sacrificed to political expediency, or ignored for political expediency, because this would be like canceling one's life insurance on account of temporary financial straits. We must be ever certain that science is adequately represented in those areas where policy will impinge on science, so that considerations of science will be included in policy formulation. International scientific activity, for example, has moved historically without regard for political boundaries, and this is one of its great strengths. This traditional nature of science must not be negated or forgotten, as it all too often is when restrictions are placed on the free movement of individuals among nations. Nothing will erode our basic traditions and our scientific leadership, and our influence, more quickly than a tendency to sacrifice basic long-term beliefs for short-term political considerations.

Moreover, the needs of science must

be adequately represented in international as well as domestic policy formulation. Radioastronomy recently almost came to an untimely end, simply through the negotiation of an international treaty on frequency allocations without adequate recognition of the needs of this young science for listening "windows." Through the good offices of the National Academy of Sciences it was possible to bring scientists and the appropriate government officials together, in time to establish a U.S. position for the Geneva International Telecommunications Union conference compatible with the needs of the radioastronomers.

International scientific activities thus carry with them many problems for government, but their benefits far exceed those problems. To achieve the benefits, however, requires that we be alert to the opportunities and that we be prepared to make some of the necessary policy decisions and commitments of resources.

Technical Components of Arms-Control Measures

I mentioned above, as a third new element in the relation of science to foreign policy, the importance of the technical components of prospective arms-control measures.

The negotiations on nuclear-test cessation have shown the importance of scientific and technological factors in the formulation of national policy in this area. These factors had to be evaluated by *ad hoc* groups that found a dearth of experimental data on which to base their conclusions. A similar *ad hoc* approach had to be employed regarding certain phases of the conference on the problem of reducing dangers of surprise attack, in which I participated more than a year ago. The *ad hoc* approach is not very satisfactory but the fact that scientific advice and evaluation were used in both these attempts to reduce military tensions is, in itself, important. It is a sign of the changing attitude and of the growing awareness on the part of policy makers that technical considerations and knowledge are essential for the formulation of sound concepts for arms-limitation measures, just as they are in formulating development plans for military hardware.

The success of future negotiations to relieve tensions by arms-limitation agreements will depend in some measure on understanding of the capabilities of proposed multilateral monitoring systems and on understanding of the inherent limitations of any monitoring system in a world of rapidly advancing technology. The limitations of technical analysis need also to be fully understood. There is no doubt, for instance, that the reliability of monitoring systems is largely a technical question. But the adequacy of such systems, from the point of view of national security, is not. It is a politico-military question. Similarly, deterrence is not a scientific concept but a politico-military one. And we must realize that political issues or disagreements cannot be resolved by technical agreement on facts; the political questions of national interest remain. I think these issues should be understood by the public as they are being understood by the policy makers. Especially we, as scientists, must understand that we can make but one of several contributions that are essential for the formulation of sound national policy.

Science and Technical Aid

I come now to the fourth, and last, of my list of "new" relations between science and foreign policy, which I called the relation of science to technical aid for less-developed countries.

The foreign aid programs supported by the United States are powered by a matrix of motivations made up of altruism, a belief that it is to our best interest to strengthen independent nations, and a desire to contain menacing philosophies. Motivation notwithstanding, it is evident that any program, any experiment, will fall short of success unless it is soundly conceived, soundly planned, and soundly executed.

In helping to achieve a sound aid program, we, as scientists, must not think in terms of developing only the more advanced scientific capability of other nations, which is often a reflection of our own standards and comfortable abundance. We must try to strike a balance between basic needs and sophisticated development. This requires an appreciation of the way in which science and engineering develop within a nation. In many lands the history of science has not been written beyond the prologue. We must, for instance, be aware of the long-term relation between primary and secondary school education and advanced research institutions.

We do little good by providing only for esoteric research facilities when a nation lacks roads, general practitioners, and machine operators. Of course, we do a disservice also when we ignore the advanced educational institutions that set a nation's standards, provide its teachers, offer a future for gifted citizens, and bring prestige to a nation or a region.

I would like to digress a moment to commend to your attention a recent report prepared by the National Academy of Sciences–National Research Council for the International Cooperation Administration, entitled "Recommendations for Strengthening Science and Technology in Selected Areas South of the Sahara." Our committee stimulated the undertaking of this important study, to be viewed as an experiment. It is an outline of the way in which assistance of a technological type should be designed to be properly utilized. It is an intelligent and realistic attempt to strike the necessary balance between basic needs and sophisticated wants, within a framework of limited resources, from within and without an area. It is also an attempt—a very successful one I believe—to show how a scientific approach can be used in the early planning stages of aid programs.

The reading of the report will have a sobering and disturbing, if not a frightening, effect on thinking individuals. It treats of selected areas of sub-Saharan Africa, of a land mass equal to that of the United States with a population one-half that of our nation —and this is only part of sub-Saharan Africa. It is an area which, within our lifetimes, will be transformed into a multiplicity of independent nations which, collectively, will greatly influence world affairs. Particularly disturbing in this study are the revelations of extreme shortages that still exist in this region—the nearly complete lack of public health measures and medical services, of communications and transportation, of the means for earning an income, of even the most elementary education facilities. Clearly, these embryonic nations need educated people in large numbers to provide not only civil servants but an understanding electorate to carry them along the path to democracy. But how can the needs for higher education, for doctors, for engineers, for political scientists, for so many other specialists be properly balanced against the need to provide even the most

primitive health measures, to provide teachers for the many millions of illiterates, and to train the artisans and skilled laborers without whom the standard of living cannot rise? Against these multiple desperate needs, indigenous efforts, our aid, and the aid of others appear so utterly inadequate that one becomes fearful lest decades will pass before the level of education and the standard of living will rise enough to make democracy viable. The question then comes to mind: Will the awakening of latent desires allow democracy the time it needs to develop—a need inherent in its evolutionary nature—or will this region fall prey to the legerdemain appeal of revolutionary authoritarianism, especially Communist ideology?

For a research scientist this report will have a sobering influence: it will point out to him that he is a luxury that can, and must, be afforded by an advanced nation like ours, whereas in Africa south of the Sahara, a nurse, an elementary school teacher, a technician —these are the luxuries.

Science impinges on aid to technologically more advanced nations also. Various government departments have for many years supported research overseas. By and large, these programs have been well run. Such programs raise some serious issues for consideration, however, for outside support of science in a given country affects the relationships between that government and its citizens and universities. Some programs, even those in support of basic research, are welcomed by many foreign scientists, yet seem an affront to others. We must, therefore, consider the effects of such programs on all who are concerned, and especially on the natural growth of the scientific communities in the recipient countries. Does such support, for instance, actually retard the development of a healthy relation between science and government in other countries? What commitments are we making for continuity of support once foreign scientists have become dependent on U.S. support—commitments from which it may be impossible to withdraw or which may cause hardship should withdrawal be necessary? What is the effect of our support on the pattern of research in a given country? And is the manner in which our support is given in this area best calculated to further good relations between the scientific communities of other countries and the United States?

We are not the only ones who are aware of these problems. In its most recent annual report, the United Kingdom's Advisory Council on Scientific Policy, addressing itself to just these questions, had this to say about U.S. research support: "Whilst we warmly welcome this substantial financial support for research in this country, we recognize that research grants, and particularly specific contracts, of this magnitude (one and a quarter million pounds annually) must have a considerable influence on the general pattern of research undertaken. We, therefore, consider it desirable that the various bodies concerned with the financing of research in our universities and other institutions should be aware both of the extent and the purpose of these numerous United States research grants and contracts. We are glad to be able to record that the United States authorities have fully appreciated the position and have shown themselves ready to cooperate with us . . ."

Of course, there are no general answers to most of the specific questions raised, for they vary with the country concerned and with the manner in which our support is given in each country. But these questions need to be asked—and answered—before support is provided. These programs cannot be operated independently of foreign policy considerations.

The Scientist's Role

I have attempted here to outline some of the ways science can contribute to foreign policy, and the effect of policy considerations on science. But to integrate the scientific with the political, economic, military, and other factors that make up foreign policy operations requires, above all, competent people who understand the relationship of science to these other factors.

If we appreciate our responsibilities, we, as scientists, may well have an important role to play in the future in the policy-making process. I think it will be a role different from the one to which we have become accustomed. I think it will demand a new breed of public servant, although I am at a loss to find the appropriate name for him. The term *political scientist* has been pre-empted for a use very different from what I have in mind. I am sure that none of us would want to be called "scientific politicians," and few indeed would dare to lay claim to "scientific statesman." But there is a significance here that is far more important than finding the right name. The role I foresee demands that this new breed of citizen-scientist shall be continually aware that the scientific community must accept its appropriate share of the responsibility for the intelligent and successful resolution of the challenges facing the world.

Another kind of individual must be recruited, too—an individual with training in science in addition to the usual disciplines of the foreign service. The general presumption is that science is so specialized that the only way to provide scientific contributions to policy formulation is to obtain advice from practicing scientists on an *ad hoc* basis as needed. I submit that as valuable as such advice is, it does not fill today's requirements for a continuing and intimate involvement in the policy-making process of competent people who also understand science and its significance to policy, and who could therefore work effectively with the practicing scientists supplying the specialized *ad hoc* studies.

Perhaps science and engineering graduates should be attracted for regular careers in the foreign service and in our other overseas programs. I believe we must also provide a better scientific background for nonscientists in the international affairs field, and that this, perhaps, is the most important measure of all. Essential to these efforts is the development of an academic field of teaching and research in the interrelationship of science and foreign affairs, in order to provide education in and better understanding of the underlying significance and opportunities of this relationship.

These are not easy tasks or tasks that can be accomplished overnight. We cannot push a button and mass-produce diplomats in striped pants and laboratory coats, in the way that we produce toasters, automobiles, and television sets.

In discussing international relations, the American historian Julius Pratt states: "Neither the tools of diplomacy nor the tools of force can be suddenly improvised for use in crisis. They must be kept in a state of readiness for use. The success of a nation's foreign policy will depend, in part, upon the efficiency and the readiness of the instruments with which that policy is pursued." We, as scientists, must do all we can to help keep the tools of our diplomacy and

the tools of our force in efficient readiness.

We have entered a new era, an era of scientific revolution, as C. P. Snow terms it, in which science and technology are transforming our way of life and the relations between nations. As practicing scientists, we cannot stand aside and simply watch this process, regardless of where it takes us; we must and we can use science and technology to achieve the humanistic goals of our free society. Let us learn to take greater advantage of the opportunities science offers us to contribute to the striving for peace in international relations and to improve the lot of man throughout the world.

Preparation of High School Science Teachers

The AAAS Cooperative Committee on the Teaching of Science and Mathematics recommends the adoption of certification standards.

The concern for better preparation of teachers in the field of science and mathematics (hereafter referred to in this report as the sciences) has been growing during the last several years. Very recently this concern has been intensified considerably as the result of new developments both nationally and internationally. A statement was made by the Cooperative Committee of the AAAS in 1946 with reference to recommended minima for the preparation of science teachers in content material (*1*). In that same report a general statement was given with reference to the breadth of preparation that was to be desired (*2*).

Purpose

It seems that it is now time (i) to re-examine our original statements, (ii) to take cognizance of the impact of those events that have transpired in the last ten years on the requirements for the preparation of science teachers, and (iii) to make additional recommendations which result from the demands of the changing circumstances.

It is well recognized that changes in state certification laws may not always be made quickly. It is our hope, however, that this information and these recommendations, even though not immediately written into certification codes, will be studied by college and university departments of education, teachers colleges, state departments of education, certification bureaus and accrediting agencies, school administrators who select science teachers, colleagues in subject matter areas, and finally by those students and teachers who are preparing to do a more effective job in teaching science in our secondary schools.

New Developments To Be Considered

Several important factors have influenced the type of recommendation we now make on the course content that prospective teachers should have.

1) *The rapid changes that have occurred in a number of the sciences in the last decade.* Astronomy, biology, chemistry, geology, mathematics, meteorology, and physics have all advanced considerably in the last ten years. Word of new advances spreads by newspapers, magazines, public lectures, and television. This stimulates the curiosity of students who then seek answers to many questions. Teachers must be prepared to stimulate further the interest in such questions, to provide sound answers for them, and to direct effective reading at the level of the student's background. The course work taken by the teachers should prepare them to keep abreast of the new developments which are often highly complex, to answer questions about them, and to direct discussion of them.

2) *College entrance with advanced standing* (*3*). A concerted move was made (beginning in 1954) by a number of the colleges and universities of this country to work with secondary schools in developing college-level courses for their most able students. In the resulting program, for example, mathematics starting in the 10th grade leads to calculus in the 12th. In chemistry, the time-equivalent of at least three semesters permits instruction at the college level, with college texts. Thus students qualify for sophomore courses on college entrance, thereby reducing duplication. In physics similar programs have been available, but unless calculus is also taken, the policy has been to recommend advanced mathematics instead of advanced physics, thus making it possible for the student to start his sophomore physics (using calculus) during his freshman year in college. Similar programs have been in effect in biology, English, languages, and history. This program, expressing confidence in our secondary schools, places

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The members of the Cooperative Committee are J. W. Buchta, American Institute of Physics, chairman; Wayne Taylor, Academy Conference of the AAAS, vice-chairman; Bernard B. Watson, Operations Research Office, Johns Hopkins University, Bethesda, Md., secretary; Leonard Olsen, American Association of Physics Teachers; Thornton L. Page, American Astronomical Society; C. L. Agre, American Chemical Society; Theodore Woodward, American Geological Institute; Richard L. Weaver, American Nature Study Society; John W. Cell, American Society for Engineering Education; Arthur L. Howland, Association of Geology Teachers; Alfred B. Garrett, Board of Directors of the AAAS; Fred H. Norris, Botanical Society of America; John R. Mayor, director of education, AAAS; Harry F. Lewis, Division of Chemical Education, American Chemical Society; W. E. Restemeyer, Engineers Joint Council; Phillip S. Jones, Mathematical Association of America; Brother G. Nicholas, National Association of Biology Teachers; George G. Mallinson, National Association for Research in Science Teaching; Bruce Meserve, National Council of Teachers of Mathematics; Robert T. Lagemann, National Science Teachers Association; and Harold E. Wise, Section Q (Education) of the AAAS.

This report contains minor revisions of the subcommittee report which was published in April 1959 in *School Science and Mathematics*. Many of the suggestions that were gathered as the result of the wide distribution of the original report have been incorporated in this final report. The major change involves an increase in the number of hours in the area of earth science (now referred to as "related science").

emphasis on the results of good teaching in high school which in turn may be rewarded by credit toward college graduation, or time for more advanced work in college. This reward is made on the basis of the college-level course programs referred to above and on examinations prepared and graded by committees of school and college teachers. Selected groups of college freshmen have taken the same examinations for use in setting grade standards.

3) *Demonstrated proficiency versus "16" credits.* More and more of the colleges and universities are emphasizing demonstrated proficiency in subject matter areas rather than merely demanding a specified number of units as a requirement for college entrance. Also more colleges over the country are adopting some kind of entrance examination as part of the method of selecting their students.

4) *More content courses to meet the problem of complexity.* The increased complexity of the fields of science makes it important for teachers to elect a greater number of hours of subject matter related to their teaching fields than has been the case in the recent past. A teacher so prepared should be able to teach an interesting, meaningful course and to answer questions posed by the better students. Hopefully, empirical presentation of subject matter will occur much less frequently. There may be other factors, but certainly these are some which should be recognized.

Pertinent Considerations

In formulating a set of recommendations for the training of high school teachers of science we are immediately confronted with several conflicting circumstances.

1) Most science teachers are required to teach several sciences, often including a course in general science, rather than just one science. This means that a teacher must have depth of preparation in a variety of areas.

2) Because of the impact of science on other areas, the science teacher should have preparation in the social sciences and humanities to help give him the kind of perspective that we like the scholar and citizen to have.

3) There are certain elements in professional education which should be helpful in giving the best performance in the classroom. These elements may be provided by courses in such areas as the psychology, philosophy, and methodology of education and especially by experience in student teaching.

The problem. Our problem, then, is (i) to recognize, in an objective manner, the role of these several new developments in the last decade, (ii) to recognize the problems that we face in building a realistic academic program for preparation of science teachers, and (iii) to make recommendations with reference to the best type of program that can be achieved to meet these changing needs.

The academic program to meet these three facets of our problem will certainly be a full one. However, if a minimum of 120 semester hours of academic work is assumed for graduation, these requirements may be met and still leave approximately one-half of the student's academic program free for the humanities, social sciences, and professional educational courses. Many students can or will have more than 120 hours of academic credit. One-half of the student's time for preparation in his teaching area seems reasonable to expect if he is to be properly prepared. Furthermore, this amount of concentration can give him such depth that it will be possible for him to build on it later with a fifth year or more of content material to improve further his competence in the science area.

In a 4-year program for teachers it seems almost impossible to prepare them to teach in widely divergent areas: for example, English teachers to teach physics, or social science teachers to teach chemistry, or physical education teachers to teach mathematics. If multiple teaching assignments are necessary, there are favorable combinations such as physics and mathematics, chemistry and physics, and biology and health.

Recommendations for Each Science Area

The courses which are recommended in each teaching area, together with supporting courses, are outlined in the following sections. Each course is designated in terms of semester hours of credit; this designation is intended only to indicate the general proportion of time and the minimum requirements.

The supporting courses which are recommended should be the basic courses in that science area and should in each case include laboratory work.

The related science courses should include geology, astronomy, and meteorology. (This area is sometimes referred to as earth science.) It is highly desirable that students have as much experience in the related sciences as possible. This can be a combined course or it may be separate courses in these areas.

The description of each course in the following subsections and tables is merely suggestive or illustrative of the possible topics and makes no attempt to prescribe all that could or should be included.

Biology

A summary of the suggested courses in biology and other sciences (in semester hours) for the preparation of high school teachers of biology is given in Table 1.

Notes

1) Description of biology courses

A) Principles of biology: characteristics of living organisms, cell theory, structural system of plants and animals, metabolism, maintenance of individual (health and disease)

B) Plant and animal physiology, anatomy, and morphology: comparative study of functional processes of cells and tissues, structure, and behavior among the major groups of plants and animals, including the microorganisms. "At least four hours should be devoted to a study of microbiology, with emphasis on principles of bacteriology, virology, and protozoology."

C) Ecology and conservation: environment, soil, populations, relationships of species, distribution of communities. Field work should be an integral part of this course. The course could be coordinated with the work in related science.

D) Developmental anatomy and genetics: growth and development, principles of heredity, evolution

E) Preparation and use of biological materials: This course should be conducted by one thoroughly conversant with the problems of biology teachers. Consideration should be given to problems of microtechnique, cell and tissue culture, field collections, and preparation and care of small organisms.

2) Fifth year. There should be a minimum of mandated semester hours in biology to permit more flexible selection of the courses

Table 1. Suggested courses in biology and other sciences for the preparation of high school teachers of biology. (For annotation, see subsection "Biology.")

Subject	Suggested courses (semester hours)							
	A	B	C	D	E	4-year total	5th year	5-year total
Biology	10	10	4	5	4	33	14	47
Chemistry						10	6	16
Physics						8	4	12
Related science						6		6
Mathematics						6	4	10
Total						63	28	91

Table 2. Suggested courses in chemistry and other sciences for the preparation of high school teachers of chemistry. (For annotation, see subsection "Chemistry.")

Subject	Suggested courses (semester hours)						
	A	B	C	D	4-year total	5th year	5-year total
Chemistry	8	8	4	8	28	15	43
Physics					8	6	14
Biology					8		8
Related science					3	3	6
Mathematics					12	6	18
Total					59	30	89

Table 3. Suggested courses in physics and other sciences for the preparation of high school teachers of physics. (For annotation, see subsection "Physics.")

Subject	Suggested courses (semester hours)					
	A	B	C	4-year total	5th year	5-year total
Physics	10	12	6	28	15	43
Chemistry				8	6	14
Biology				8		8
Related science				3	3	6
Mathematics				12	6	18
Total				59	30	89

Table 4. Suggested courses in physics, chemistry and other sciences for the preparation of high school teachers of both physics and chemistry or of physical science. (For annotation, see subsection "Physics and Chemistry; Physical Science.")

Subject	Suggested courses (semester hours)					
	A	B	C	4-year total	5th year	5-year total
Physics	8	6	4	18	12	30
Chemistry				18	12	30
Biology				6		6
Related science				12		12
Mathematics				12	6	18
Total				66	30	96

Table 5. Suggested courses in mathematics and supporting areas for the preparation of high school teachers of mathematics in grades 7 to 12. (For annotation, see subsection "Mathematics.")

Subject	Suggested courses (semester hours)								
	A	B	C	D	E	F	4-year total	5th year	5-year total
Mathematics	12	3	3	6	3	3	30	15	45
Physics							8		8
Supporting areas							22	15	37
Total							60	30	90

which will be of most benefit to the teachers. "Cultural" courses in general science should be allowed (history of science, problems of the atomic age, laboratory techniques in more than one science, and so on). However, 25 percent of the year should be devoted to definitely biological topics such as radiation biology, microbiology, and taxonomy. It is to be understood that the taking of further courses in the biological sciences as electives should be encouraged.

3) Description of courses in other sciences recommended for biology majors. Principles of inorganic and organic chemistry, particularly as it applies to living things. Laboratory work should be included. Biochemistry is recommended in the fifth year. It is expected that standard courses in physics, earth science, and mathematics will be taken.

Chemistry

A summary of the suggested courses in chemistry and other sciences (in semester hours) for the preparation of high school teachers of chemistry is given in Table 2.

Notes

1) Description of chemistry courses
   A) General principles: composition and structure of matter, atomic and molecular theory, states and transitions of matter, stoichiometry, nature of solutions, periodic tables and relationships, rates of reactions and equilibrium, ionic equilibrium and properties of electrolytes, oxidation-reduction and electrochemistry, energy relationships and colloidal state
   B) Organic chemistry: nomenclature, hydrocarbon series, functional groups and their basic reactions, typical methods of preparation, application
   C) Analytical chemistry: gravimetric and volumetric and instrumental methods, their applications and limitations
   D) Physical chemistry: determination of precise physical properties and the application of these data to problems of reaction rates, equilibrium systems, and structure determinations.
2) Fifth year. For the fifth year the chemistry courses should include advanced inorganic chemistry (re-

Table 6. Suggested courses for the teacher who is preparing to teach mathematics as a second subject. (For annotation, see subsection "Mathematics as a second subject.")

Subject	Suggested courses (semester hours)					
	A	B	C	4-year total	5th year	5-year total
Mathematics	12	3	3	18	12	30
Physics, chemistry, or other "second" subject				18	12	30
Supporting courses for mathematics and second subject				24	6	30
Total	12	3	3	60	30	90

lation of structure to properties, periodic system, typical reactions, and the application of physical chemical principles to inorganic systems); biochemistry (fundamental reaction systems of living organisms); and radiochemistry (general principles, including some simple measurements).

3) Description of supporting courses. The other supporting courses should be the basic courses in physics, biology, mathematics, and related science.

Physics

A summary of the suggested courses in physics and other sciences (in semester hours) for the preparation of high school teachers of physics is given in Table 3.

Notes

1) Description of physics courses
   A) Introductory course: this should be a course which pursues in depth the important and basic principles of physics. Some of the most important topics are Newton's laws of motion; conservation of mass, energy, and momentum; conservation of charge; waves and fields; molecular structure of matter; and structure of the atom. Problem solving and laboratory experience are important aspects of this course. The laboratory especially must give the student first-hand knowledge of the way in which a physicist approaches an experimental problem.
   B) Intermediate courses: The prospective high school physics teacher should have one-semester courses in each of the following subjects: physical mechanics, heat and thermodynamics, optics, and electricity and magnetism. Emphasis should be on thorough quantitative treatment of a limited number of important topics in these areas of classical physics. There should be some advanced laboratory work associated with these courses. Institutions which are able to offer this material in one substantial, integrated course should do so, but it must not be a survey course. It would be most desirable for these courses to be based on calculus as a prerequisite.
   C) Modern physics: The development of atomic and nuclear physics should be traced through study of the phenomena, concepts, and experiments which are important to the understanding and appreciation of this newer area of physics. Again, the number of topics considered should be consistent with the goal of understanding emphasized in paragraphs A and B above. This course should utilize the mathematics background of the student and should have a well-developed laboratory program.
2) Description of chemistry courses. The chemistry courses should include general, organic, and physical chemistry. Laboratory and problem work should be stressed. Emphasis should also be placed upon the principles which unify the many facts of chemistry.
3) Description of other suggested courses. The related science course should be selected from the special list appearing in this report.

Physics and Chemistry; Physical Science

A summary of the suggested courses in physics, chemistry, and other sciences (in semester hours) for the preparation of high school teachers of both physics and chemistry or of physical science is given in Table 4.

Note

1) In many of this country's schools it is necessary for the science teacher to teach several sciences—for example, both physics and chemistry. Some teachers must be prepared to do this in spite of the fact that it is not possible to include in an undergraduate program all the work listed as essential to a strong preparation in both areas. Table 4 outlines a reasonable though not ideal program for these teachers. To follow this program it is necessary to allocate to the sciences a few of the hours which are considered highly desirable for preparation in the social sciences and the humanities. It must also be recognized that, in spite of this, this program may not provide a completely adequate background for graduate study in a particular science.

Mathematics

A summary of the suggested courses in mathematics (in semester hours) for the preparation of high school teachers of mathematics is given in Table 5.

Notes

1) Teaching area. In this day of changing curricula, as never before, a thorough preparation in mathematics is imperative for all mathematics teachers in grades 7 to 12. Since, as with the sciences, there are schools which must employ persons to teach another subject in addition to mathematics, and since such persons often cannot complete in an undergraduate program all the work essential to strong preparation in two areas, an initial program for these people is suggested in the next subsection.
2) Description of mathematics courses. On the undergraduate level, minimum requirements in several areas of mathematics are specified. On the graduate level, only the additional number of hours is specified.
   A) Analysis: Whether done in high school or college, adequate work in trigonometry, college algebra, analytic geometry, and calculus (with at least 6 semester hours in calculus) must be included in the teacher's preparation. For many undergraduate programs this will necessitate more than the 12 hours listed. Additional hours, if available within the 12-hour minimum, may be selected from

Table 7. Suggested courses for teachers of general science. (For annotation, see the subsection "General Science.")

Suggested courses	Semester hours
Biology*	10
Chemistry*	10
Physics*	12
Related science	6
Mathematics†	6
Subtotal	44
Other‡	16
Grand total	60

*These areas should include some work in genetics, organic chemistry, and modern physics. †Where possible this should include an introduction to the calculus. ‡These 16 semester hours of upper division work should be selected from two or more of the four science fields (excluding mathematics) listed.

advanced calculus, differential equations, and infinite series.

B) Algebra: courses selected from abstract algebra (groups, rings, fields, linear algebra, vector spaces), matrices, theory of equations, and number theory. (See also the courses described in paragraph D.)

C) Geometry: courses selected from metric and other geometries (projective, affine, inversive), non-Euclidean geometries, differential geometry, and topology. (See also the courses described in paragraph D.)

D) Foundations of mathematics: theory of sets, mathematical or symbolic logic, postulates for geometry, postulates for algebra, postulates for arithmetic, the real and complex number systems, the history of the development of mathematical ideas. (Some of the material and course hours specified here could be included under paragraphs B and C if a school chose to do so.)

E) Probability and statistics: emphasizing probability and statistical inference

F) Applications: courses from mechanics, mathematical physics, mathematical astronomy, actuarial mathematics (finite differences, empirical formulas and interpolation, numerical analysis), and mathematics as used in the behavioral sciences (theory of games, linear programing, operations analysis, econometrics)

3) Description of courses in supporting areas: The undergraduate requirement should include a year's course in physics and a course in at least one other science. The student's work in the foundations of mathematics suggested in paragraph D above should be further supported by study in philosophy, logic, and symbolic logic. In addition, his perceptions of the nature of mathematical models and the relationships between mathematics and the areas in which it is most used should be sharpened by additional work in science, such as courses in chemistry, astronomy, biology, geology, and meteorology and the other courses mentioned in paragraph F above.

Mathematics as a Second Subject

A summary of the suggested courses in mathematics and other sciences (in semester hours) for teachers who are preparing to teach mathematics as a second subject is given in Table 6.

Notes

1) As noted in the previous subsection, we believe that 4-year programs providing partial preparation in several areas are necessary at this time in order to staff small junior and senior high schools. We urge that teachers with such a "minor" in mathematics extend their training as rapidly as possible via extension courses, summer sessions, and "in-service" or summer institutes.

2) The courses under the column headings A, B, and C are the same here as in Table 5. A "minor" in mathematics should never contain less than an introductory calculus course and some experience in algebra and geometry beyond college algebra and analytic geometry.

General Science

A summary of the suggested courses (in semester hours) for the preparation of high school teachers of general science is given in Table 7.

Assumptions. The suggested requirements are predicated on the following assumptions.

1) A teacher who has completed the specified major in any of the fields previously listed in this report (biology, chemistry, physics, and physical science) will, with a minimum of additional background, be qualified to teach general science.

2) There is need for teachers to specialize in the teaching of general science at the junior high school level.

3) The science courses for the general science specialist should be such as to permit him to begin graduate work in one of the sciences if he later decides to do so.

4) The teachers of general science should have a broad background in science and mathematics plus specialization in one or more areas of science.

Miscellaneous

1) *The science methods course.* It is assumed that a science methods course will be available in each of these curricula. The two essential conditions for this to be a valuable course are centered in the qualifications of the instructor. He must be a person who is a scholar, well and solidly informed in the field of science; and he must be cognizant of and intelligently sympathetic toward the problems of secondary education. Given these qualities as a *sine qua non*, the question of the department or school in which the course should be taught becomes irrelevant and is a matter to be decided in terms of local institutional circumstances.

2) It is recommended that student-

Table 8. Summary of the requirements.

Suggested courses	Common foundation	Major in				
		Biology	Chemistry	Physics	Physical science	General science
Biology	6	27	2	2		4
Chemistry	8	2	20		10	2
Physics	8			20	10	4
Related science	3	3			9	3
Mathematics	6		6	6	6	
Subtotal	31	32	28	28	35	13
Common total		31	31	31	31	31 + 16*
Grand total		63	59	59	66	60

* Sixteen units of upper division work selected from two or more of the four science fields (excluding mathematics) listed above.

teachers receive training in preparing and planning materials for laboratory work and demonstration purposes.

3) *The fifth year.* A fifth year of work is strongly recommended. At least half of the course work during this year should be in science courses.

4) *Related science.* The elements suggested for inclusion of the earth science course are enumerated in the previous section. No statement is made about preparation of teachers to teach related science alone. Recommendations for preparation of teachers in such basic sciences as chemistry, physics, biology, mathematics, and physical or general science have been considered of major concern at this time.

5) *Credit to maintain certification.* Teachers who are required to take a certain number of credit hours to maintain their certificates after several years of teaching should take basic science courses in their teaching field unless they can show sufficient background of *recent* course work in that field.

6) *A synoptic view.* A survey of the requirements for the five science majors in this report (biology, chemistry, physics, physical science, and general science) shows that there exists a pattern of background common to all. Thus, each science major can be thought of as consisting of this common foundation plus certain additional preparation.

Specifically, the pattern of background common to all of the science preparations (but not including preparation for mathematics teaching) is, in semester hours, as follows: (i), biology, 6; (ii), chemistry, 8; (iii), physics, 8; (iv), related science, 3; (v), mathematics, 6—or a total of 31 semester hours.

Because there is so much in common among the five curricula in science, it is quite practical for the prospective teacher to qualify in at least two of the five science areas involved in this report. Specifically, it is quite practical for the prospective teacher of biology, chemistry, physics, or physical science to add a few more courses and qualify also as a teacher of general science. This combination, known in some places as a "comprehensive science major," is an ideal preparation for the modern teacher of science to high school students, although it must be recognized that it does *not* prepare him for more advanced study.

For the four-year programs, the requirements are summarized in Table 8. This synthesis of recommendations also suggests multiple qualification in secondary school science—for example, a teacher prepared in biology could also qualify in general science by taking four additional units in physics and three additional units in related science. By the addition of 10 units in physics and 9 units in related science, the major in chemistry could qualify for teaching physical science.

References and Notes

1. *School Science and Mathematics* (Feb. 1946).
2. The recommendations were as follow. (i) A policy of certification in closely related subjects within the broad area of science and mathematics should be established and put into practice. (ii) Approximately one-half of the prospective teacher's 4-year program should be devoted to courses in science. (iii) Certification to teach general science at the 7th, 8th, and 9th grade levels should be granted on the basis of a broad preparation including college courses in all the subjects concerned in general science. (iv) Colleges and certification authorities should work toward a 5-year program for the preparation of high school teachers. (v) Curriculum improvements in the small high schools should go hand in hand with improvement in teacher preparation.
3. "Bulletin on Advanced Placement Program" (College Entrance Examination Board, New York); B. Norton, "College admission with advanced standing," *J. Chem. Educ.* **33**, 232 (1956).

Milton Charles Winternitz, Pupil of William Henry Welch

In setting down the above title I felt no temptation to write "Milton Charles Winternitz, Pathologist." For if Winternitz were so described, where today would we find pathologists?

Four inscriptions adorn the walls of the School of Medicine at Yale. The first, over the main portal, announces: "The Institute of Human Relations–The Sterling Hall of Medicine." Here, high enough and plain for all to see, is set forth the great objective Winternitz set for medical science and the central ideal for which he strove—medicine, a study of the total man. To Winternitz, catching up the sparks of this lofty concept from his great teachers, endowed with youth, with brains, and with the courage and energy of a crusader, it mattered little that material assets at Yale were few when he arrived. You know the exciting story: bricks and mortar, the men, and always the ideas—ideas born of the happiness of constant work, of constant thought, and of steadily accumulating experience. "Yale will study man—total man," he said. With bewildering rapidity there came into existence, besides the magnificent medical school, a conception of the enormous importance of preventive medicine and public health, broad applications for psychiatry, the neurological study unit, the atypical-growth research unit, the dental study unit, the School of Nursing, and above all, the concept for the Institute of Human Relations. In each major field young men of extraordinary promise were assembled. But Winternitz, the dean, was not complacent. Often he said, "It's easy enough to grow apples, but can we grow better apples?" For him, any idea of a template for replication was unthinkable; all was new—spontaneous generation, or as some have said, "spontaneous combustion"! There is no doubt that things caught fire in New Haven. With what pride must he have viewed in 1932—side by side—the magnificent Institute of Human Relations and the Sterling Hall of Medicine, symbolizing then as they do today the ideals and ideas of many generations of teachers and students yet to come.

Over the inner doorway of the Sterling Hall of Medicine in the Greek of Plato is written: "Carrying torches,

they will pass them on, one to another." No need to say who put that there! Teaching for Winternitz dealt with inspiration and with inspiration alone. Vivid in his own memory was the joy he had in learning from William Henry Welch and the others at Johns Hopkins. If the student could only be inspired to think, learning would follow. "Universities," he said, "should be interested primarily in providing opportunity for learning and not in giving instruction: teaching need enter only so far as there is failure to learn. . . . A university should protect learning against the inroads of teaching or methodology of all sorts." These thoughts, translated of course into action, led to the freedoms of the Yale plan for medical education. The students have done well under this system, and I have yet to hear a graduate of the school decry it.

To the individual student, Winternitz always seemed, and often was, like an animal about to spring, so that alertness in class was essential for survival. His constant probing beyond the obvious was at times confusing, but it stimulated thought, and we never doubted that we were close to great events when he was with us. Even when speaking to the class he seemed to speak to each of us alone.

"Here is the place where death rejoices to be of aid to life." These humble words, in Latin, are inscribed over the Brady Laboratory of Pathology. Winternitz in his early days as dean worried about pathology as a science, but later on his worry ceased. He believed that pathologists in the old sense—morbid anatomists—would find their niche chiefly in service in hospital laboratories, and that they would play, in more academic surroundings, a decreasingly important role. He conceived the new pathology to be based on chemistry, on physics, and on physical chemistry, with morbid anatomy remaining as a yardstick. He became impatient with the microscope and with men with microscopes. For him, the new pathologist might have his basic training in any phase of medical science, and he must, among all men in medicine, be eclectic in his viewpoint, and be able to make correlations of importance and to synthesize ideas. With the enthusiasm of a man half his age, Winternitz welcomed in the era

Milton Charles Winternitz (1885–1959) [From a sketch for a portrait by Deane Keller]

of histochemistry, of electron microscopes, and of radioactive isotopes. That is, he welcomed these things for the younger men; he himself never mastered any of the more modern techniques.

Winternitz' own investigative work was carried out with the "old tools." He was too much of an administrator to get along easily with natural phenomena. Thus, he was often impatient when nature refused to follow a course he had laid out! Yet no matter how negative the report of a student's experiment, he always saw in it some budding principle of importance that would send the younger man off with renewed patience and determination. His love of administration runs through all his scientific work. One has but to look at the beautifully organized and illustrated monographs on influenza, on war gas poisoning, and on arteriosclerosis to sense his extraordinary ability for organizing research. Later, when he was no longer in the laboratory, he continued to organize. The three-volume *Fasciculus on Chemical Warfare Medicine*, edited under his direction during World War II, testifies to this. There followed, during his association with the National Research Council, the magnificent volumes of the *Atlas of Tumor Pathology* and, among many other creative projects, two active centers for the exchange of scientific information: the Chemical–Biological Coordination Center and the Bio-Sciences Information Exchange. During all of this time, too, he was leading, as director of the Board of Scientific Advisers, the Jane Coffin Childs Memorial Fund for Medical Research into the support of important projects on the fundamental aspects of growth. Whether in the laboratory, in the hospital, in a scientific meeting, or in the board room of a foundation, at the local or the national level, he always spoke out loud and clear—and usually those present listened.

The last inscription at Yale that comes to mind in writing of Winternitz is the most personal. It is a barely legible "MCW," rudely scratched in the pine panel over the door of the elegantly appointed Beaumont room in the Sterling Hall of Medicine. Hoisted on the shoulders of his friends and students, Winternitz carved it there at the climax of a party at the time of his retirement in 1950. This seemingly trivial act represents to me the very essence of the man, the very human side of this "human dynamo which ran at full speed through light and darkness." Much has been written and many have known of "Winter's" catalytic qualities. Many I know would have it, rather, that he was an inflammatory agent, causing rubor, calor, turgor, and dolor on contact! Winter the showman is also known to all. But not many of his colleagues over the world in science know of his extreme kindness and personal sacrifices for individuals sick or in trouble. How many know of his modesty or have witnessed the humble soul-searching that his high ideals, his bad mistakes, and his volatile temperament so often made necessary for him? His students loved him well. But I suspect that not even they really know how deep and lasting was his love for the medical institution he raised and cherished for so many years in New Haven. The sprawling initials over the door—was this the thoughtless act of a carefree moment? I doubt it. Those who were there went home silently.

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Science in the News

U.S. Meteorological Satellite Cameras Photograph Cloud Cover

The U.S. meteorological satellite TIROS I (for television and infrared observation satellite) was launched at 6:40 A.M. on Friday, 1 April 1960, from the Atlantic Missile Station at Cape Canaveral, Fla. The 270-pound satellite is by far the heaviest yet launched by the United States and has achieved an orbit remarkably close to that desired in both height and inclination. The intended orbit was to have been circular at about 400 nautical miles above the earth's surface; the actual orbit, according to preliminary calculations, is 378.7 nautical miles at perigee and 407.2 at apogee, or 435.5 and 468.28 statute miles, respectively.

The north inclination to the equator of the orbit is 48.327°, which is within 0.0003° of the angle desired. Consequently, the orbit will extend from about 48° north to 48° south latitude, as shown in Fig. 1. The orbital time is 99.15 minutes.

The satellite, shown in Fig. 2, looks like a large hatbox, 42 inches in diameter and 19 inches high. Its top and sides are almost completely covered by banks of solar cells—some 9200 in all. Extending beneath the payload are four transmitting antennas. A single receiving antenna is located on the top.

Primary Mission of TIROS

The primary mission of TIROS is to send back pictures of the cloud cover. Its two television cameras will be able to take pictures every 30 seconds for 32 exposures. The 500-line pictures will be stored on magnetic tape and read off on demand from ground control stations at Fort Monmouth, N.J., and Kaena Point, Hawaii.

In addition to its TV cameras and associated equipment, the satellite contains beacon transmitters, attitude sensors, and telemetry circuits. Power is supplied by nickel-cadmium batteries charged by solar cells. Power output is expected to average about 19 watts.

The two TV cameras differ in coverage and resolution. The side-angle camera is designed to cover, at 400 miles' altitude, an area of cloud cover roughly 800 miles on a side. The narrow-angle camera will photograph a smaller area located within the wide-angle camera's view.

Identical except for lens equipment, each of the cameras is the size of a water glass and has a ½-inch Vidicon tube especially designed for use in satellites. Each camera consists of two parts: a Vidicon and a focal-plane shutter which permits still pictures to be stored on the tube screen. The two TV systems and their associated equipment operate independently of one another.

At the ground stations, pictures will be displayed on Kinescopes for immediate viewing and photographing. Photographic data will also be sent to the U.S. Naval Photographic Interpretation Center for developing and processing.

Around the payload are nine solar sensing cells. They measure the position of the satellite with respect to the sun. This information is transmitted to the ground stations with the TV transmission, where it is processed by a computer to show which direction is north in each picture.

Two beacon transmitters, operating on 108.00 and 108.03 megacycles per second, respectively, each with a power output of 30 milliwatts, will be used for tracking purposes. They can be modulated to provide information on satellite attitude, environmental conditions, and satellite-equipment operation. For back-up purposes, both frequencies carry the same data. Each of the photographic data acquisition stations is equipped with tracking antennas.

When the payload separated from the third stage of the Thor-Able rocket, it was spinning at about 136 revolutions per minute. Pictures taken from a vehicle with this rate of spin would be blurred. About 10 minutes after payload separation a mechanism to slow the revolutions to 12 per minute (within operating limits for the camera) went into operation. The mechanism consisted of two weights attached to cables wound around the satellite. As the weights unwound they slowed the rate of spin and then dropped off automatically.

The satellite is expected to remain stable in its orbit as long as it maintains a minimum spin rate of 9 rev/min. When spin slows to the minimum, ground-activated control rockets will speed the satellite's rotation up to 12 rev/min. There are three pairs of these jets located around the baseplate of the TIROS. Each set can be used once. It is estimated that spin-up will be necessary only every 20 days.

An infrared detector within the payload senses the crossing of the earth's horizon. This information is transmitted to the ground stations for processing to determine the attitude in space of the satellite's spin axis; it also can be used as a basis for computing spin rate.

Since TIROS is spin-stabilized, it will not be "looking" at the earth at all times. On the basis of tracking information, Fort Monmouth and Kaena Point will program the cameras to take photographs only at times when the satellite is viewing the earth and when the area to be photographed is in sunlight. This is done by setting a timer. Program commands can be given as much as 5 hours in advance. Pictures taken while TIROS is out of range of the ground stations will be stored on tape for later relay. In the remote mode, the timer starts the camera, power, and transmitter functions. Each read-out wipes the tape clean. It immediately rewinds for its next recording.

When the satellite is within range of a station, ground command can turn on the cameras directly, and photographs taken above the station will immediately be relayed to earth, bypassing the magnetic tape.

The equipment is expected to operate for about 3 months, but the satellite will stay in orbit for many years.

The first stage of the launching was

an improved Thor intermediate-range ballistic missile with a weight of more than 100,000 pounds and a thrust of about 150,000 pounds. The liquid-fueled Thor propelled the vehicle for about 160 seconds after launching. During this time, the rocket was controlled by roll-and-pitch programmers. During the latter part of the second-stage boost, a plastic nose-fairing covering the third stage and satellite was jettisoned.

The second stage was powered by a liquid-fueled engine which was adapted and modified from earlier Vanguard and Thor-Able rocket vehicles. At the top were six small rockets to spin the third stage. The second stage, which fired immediately after first-stage separation, weighed more than 4000 pounds and had a thrust of about 7500 pounds. It contained a radio-guidance system developed by Bell Telephone Laboratories and Western Electric Company, which is the same as that used in the Titan ICBM. This stage propelled the vehicle for about 100 seconds. At burn-out the spin rockets ignited, causing the third stage and the payload to rotate at 136 rev/min. The spin stabilizes the trajectory of the third stage and payload. About 1½ seconds after the spin rockets fired, the second stage was separated by a retro-rocket.

The third stage was a solid-propellant rocket, adapted from the Vanguard and Able I rocket vehicles. It propelled the payload to orbital velocity (about 18,000 miles per hour), weighed more than 500 pounds, and had a thrust of about 3000 pounds.

The third stage coasted for about 6½ minutes before ignition. It then went into orbit still attached to the payload. Separation occurred about 25 minutes after third-stage burnout when a set of springs forced the third stage and payload apart. Burned out, the empty third-stage casing weighs about 50 pounds.

Responsible Agencies

Over-all responsibility for the project rested with the National Aeronautics and Space Administration, but several government agencies and industrial organizations cooperated in various phases of the assembly and launching.

Meteorologists in the Meteorological Satellite Section of the Weather Bureau will be responsible for analyzing and interpretating the cloud-cover data. Assisting NASA and the Weather Bureau in weather-data analysis will be the Air Force Cambridge Research Center, Allied Research Associates, Air Weather Service, Navy Research Weather Facility, and the Army Signal Corps. The U.S. Naval Photographic Interpretation Center will develop and process photographs before they are distributed for research purposes.

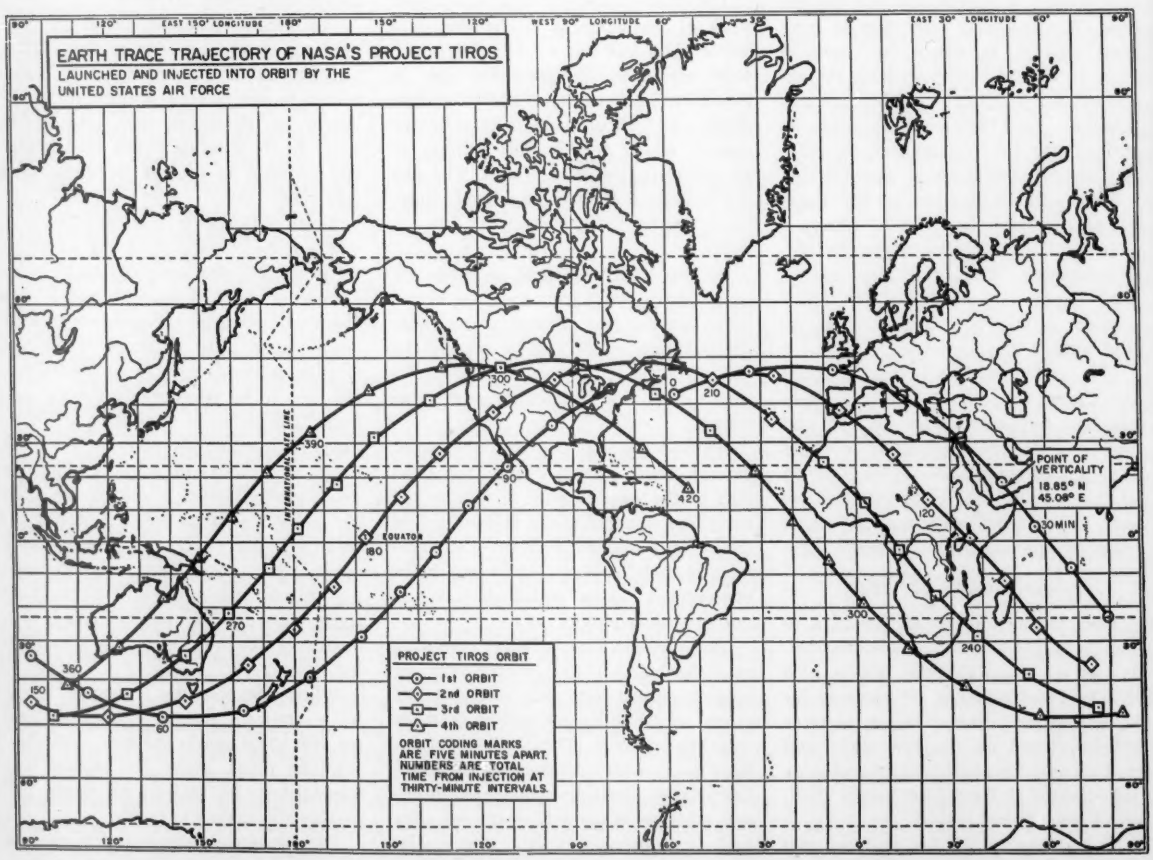

Fig. 1. The orbital path for TIROS I, closely approximated by the actual path. In the next 3 months the satellite will sweep over every point in the belt from 48°N to 48°S. The time after launching given for the fourth orbit near the Greenwich meridian was 330 minutes, not 300.

Eisenhower and Macmillan Agree on Test Ban Approach

Following is the statement released on 29 March by President Eisenhower and Prime Minister Macmillan on their talks at Camp David. The United States and Britain agree to accept the Soviet Proposal for a moratorium on underground nuclear tests provided the Soviet Union accepts a satisfactory system of international inspection.

President Eisenhower and Prime Minister Macmillan have discussed the present position of the nuclear tests conference at Geneva between the United States, United Kingdom and the Soviet Union.

It has been and remains the earnest desire of both the United States Government and Her Majesty's Government in the United Kingdom to achieve, by international agreement, the total prohibition of all nuclear weapons tests, under effective international control.

When the Geneva conference began seventeen months ago, there was reason to hope from the preliminary scientific discussions which had preceded it that there would be no insuperable technical or scientific difficulties in establishing an effective control system capable of detecting nuclear tests of all kinds.

Subsequently, however, it appeared from further scientific research that in our present state of knowledge there are great technical problems involved in setting up a control system which would be effective in detecting underground nuclear tests below a certain size. It is, however, the sincere hope of the President and the Prime Minister that an agreed program of coordinated scientific research, undertaken by the three countries, will lead in time to a solution of this problem.

Progress Held Possible

Meanwhile, the President and the Prime Minister believe that progress can be made toward their ultimate objective of a comprehensive agreement. They have agreed that much has been accomplished in these Geneva negotiations toward this objective.

They point out that in the effort to achieve the early conclusion of a treaty there are a number of important specific problems to be resolved. These include the questions of an adequate quota of on-site inspections, the composition of the control commission, control post staffing and voting matters, as well as arrangements for peaceful purposes detonations.

They believe that negotiation on these points should be speeded up and completed at the earliest possible time.

The Prime Minister and the President have agreed that as soon as this treaty has been signed and arrangements made for a coordinated research program for the purpose of progressively improving control methods for events below a seismic magnitude of 4.75, they will be ready to institute a voluntary moratorium of agreed duration on nuclear weapons tests below that threshold, to be accomplished by unilateral declaration of each of the three powers.

In order to expedite progress, the President and the Prime Minister have agreed to invite the Soviet Government to join at once with their two governments in making arrangements for such a coordinated research program and putting it into operation.

It is to be understood that, once the treaty is signed, ratification will have to follow the constitutional processes of each country.

The President and the Prime Minister have agreed to give instructions to their delegates at Geneva in accordance with the spirit of this declaration.

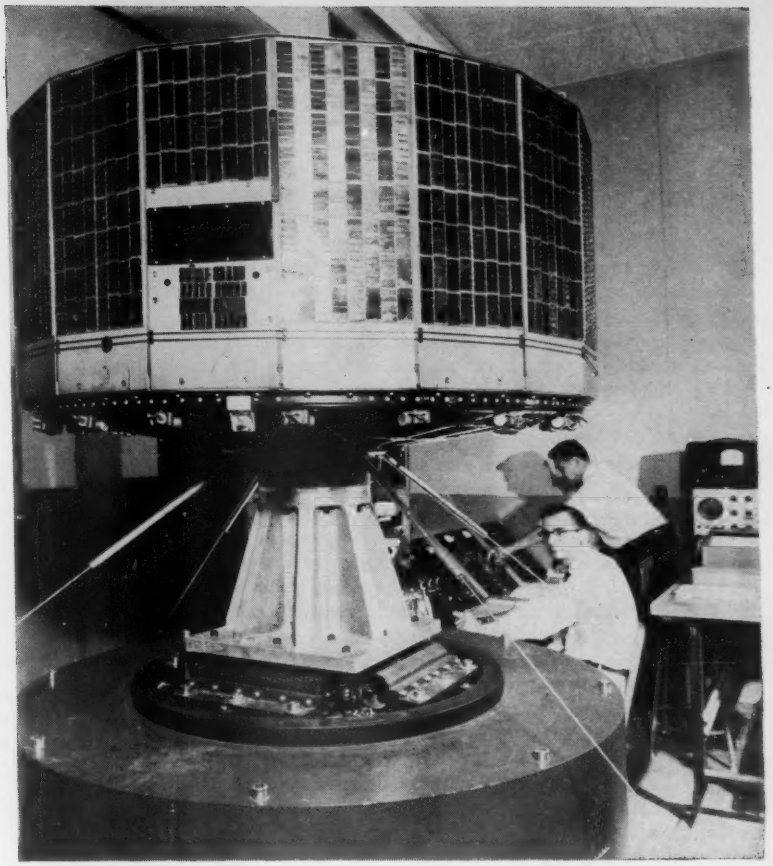

Fig. 2. The satellite is given a vibration test at the Astro-Electronic Products Division of the Radio Corporation of America, Princeton, N.J. (see page 1031).

United States To Pay Indemnity for Cranberry Losses

On 30 March the White House announced that the Department of Agriculture will offer to pay about $10 million to cranberry growers who, through no fault of their own, sustained losses on berries harvested in 1959. Payments will be made under a law originally enacted in 1935.

The White House announced that

compensation would be about $8 a barrel for clean, marketable berries. James C. Hagerty, White House press secretary, added, according to the Associated Press, that the growers normally would have realized $12 a barrel.

Some growers suffered losses last fall when the Secretary of Health, Education, and Welfare, Arthur S. Flemming, warned the public that a part of the current cranberry crop was contaminated by aminotriazole, a weed killer. Flemming based his action on a statement in the Federal Food, Drug, and Cosmetic Act that says: "no additive shall be deemed safe if it is found to induce cancer when ingested by man or animal. . . ."

Aminotriazole is registered with the Department of Agriculture as an economic poison. If used in cranberry bogs within a few days after harvest, it will not be incorporated in the berries produced the following year. But it will be incorporated in the berries if it is used during the growing season.

The White House said that the present action "represents an effort to assure the wholesomeness of all cranberries offered to the public, restore consumer confidence in the product, and assist those cranberry producers who suffered an impairment of their market as a consequence of improper use, by a few growers, of the weed-killing chemical aminotriazole."

The Department of Health, Education, and Welfare will undertake, in cooperation with the growers, a program of testing and certification, the White House said. No payments will be made on berries found to be contaminated.

Various alternative methods of assisting the cranberry growers have been explored. The indemnification procedure, which has been found to be legally appropriate by the Comptroller General, was chosen as the only satisfactory approach.

Details of the offer to make such payments will be issued shortly by the Department of Agriculture.

Archeologists Plan Excavations in Aswan Dam Region

An emergency program to rescue archeological treasures from a man-made flood in Egypt and the Sudan was announced in March by the Oriental Institute of the University of Chicago. The institute is planning a 5-year program of exploration, excavation, and recording of antiquities in the region stretching from Aswan, in the United Arab Republic, to the third cataract of the Nile, in the Sudan. The region will be completely inundated over the next 5 years by a lake formed by the Aswan High Dam, on which construction was begun this year by the United Arab Republic. The waters will submerge a score of major temples and tombs and hundreds of other known but unexplored sites.

The Oriental Institute's current operations in the United Arab Republic are directed from Chicago House at Luxor, Egypt. Chicago House is the headquarters of the institute's epigraphic survey. Present action followed a recent appeal by the director-general of UNESCO, Vittorino Veronese, to save the monuments of the region to be flooded.

The Oriental Institute's program will be carried out under provisions contained in invitations issued by the United Arab Republic and the Sudanese Government. Excavators will be allowed to keep at least 50 percent of their finds, except for certain items which are unique or essential for completing national collections. (Ordinarily, excavators are not allowed to take antiquities from the country in which they are found.) Later, excavators will be permitted to work in certain areas heretofore closed to them.

Administration of the program has been placed in the hands of a committee of five scholars: Keith C. Seele (program director), Oriental Institute professor of Egyptology; Pierre Delougaz, Oriental Institute associate professor and curator of the Oriental Institute Museum; Richard C. Haines, Oriental Institute instructor and field director, Nippur Expedition; Thorkild Jacobsen, Oriental Institute professor; and John A. Wilson, Andrew MacLeish Distinguished Service Professor at the Oriental Institute and the only American member of UNESCO's consultative committee of experts in the international campaign to save the monuments.

News Briefs

In memoriam. Establishment of a Durand fellowship in aeronautical engineering, in memory of one of aviation's greatest scientific pioneers, has been announced by Joseph M. Pettit, dean of the Stanford University School of Engineering. The late William Frederick Durand, who started aeronautical engineering study at Stanford early in this century, died in 1958 at the age of 99. Initial support for the fellowship came from Durand himself, for he left a legacy of $20,000 to assist "worthy Stanford students in aeronautical engineering." Gifts from Durand's admirers, students, and colleagues are expected to increase the fund in coming years.

* * *

Medical-school research costs. Operating expenditures for scientific research in medical schools in the United States have increased six times in 10 years, rising from $17.1 million in 1948 to $105.5 million in fiscal year 1958, according to the National Science Foundation. This is one of the major findings of a new NSF study of research in medical schools, published as *Funds for Research in Medical Schools 1957–58*, number 17 of the series *Reviews of Data on Research & Development*. Other reports covering colleges and universities in general, engineering schools, agricultural experiment stations, and federal contract research centers are in preparation. Copies of the medical-school study are available at 10 cents apiece from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

* * *

Prague nuclear conference. The International Atomic Energy Agency has accepted the invitation of the Government of Czechoslovakia to arrange an international symposium, to be held in Prague, on chemical effects of nuclear transformations. The symposium will be held 24–27 October 1960; member governments and interested international organizations have been invited to nominate participants.

* * *

Economic botany. The Society for Economic Botany will hold its first annual meeting at Purdue University, 21–22 May. Highlight of the meeting will be a symposium on integrated research in economic plants, with special emphasis on drug and essential-oil plants. There will also be two sessions for contributed papers on any aspect of economic botany. The new society endeavors to promote interdisciplinary exchange of information about all activities which pertain to the past, present, and future uses of plants by man. Applications for membership should be sent to Dr. Quentin Jones, New Crops Research Branch, Beltsville, Md.

Scientists in the News

Paul B. Sears, ecologist and chairman of the conservation department at Yale University, will retire on 30 June.

Sears served as president of the AAAS in 1956 and in 1958 was elected to membership on the National Science Board.

He received a bachelor of science degree from Ohio Wesleyan in 1913, a master's degree from the University of Nebraska in 1915, and a doctoral degree, summa cum laude, from the University of Chicago in 1922. From 1927 to 1938 he was professor of botany and chairman of the department at the University of Oklahoma, and from 1938 to 1950 he held the same positions at Oberlin. He joined the Yale faculty in 1950.

Alvin M. Weinberg, director of Oak Ridge National Laboratory, and **George W. Beadle**, professor and chairman of the division of biology at California Institute of Technology, have been appointed to the President's Science Advisory Committee.

H. E. Menker, head of the chemistry development department of Tracerlab, Inc., Richmond, Calif., has been named director of the analytical division of the Health and Safety Laboratory, New York Operations Office, U.S. Atomic Energy Commission.

David W. Bareis, formerly on the staff of Atomics International, is now a research scientist in the nuclear systems division of the Marquardt Corp., Van Nuys, Calif.

Harold H. Zeiss, research associate with the Monsanto Chemical Co., Dayton, Ohio, is taking a year's leave of absence, beginning in September, to study at the universities of Munich and Heidelberg in Germany.

Bernard E. Conley, director of the committee on toxicology of the American Medical Association, has accepted a position as medical research consultant to Hoffmann-La Roche, Inc., Chicago, Ill.

Vincent Massey, a member of the department of biochemistry at the University of Sheffield (England) is visiting associate professor of biochemistry at the University of Illinois until 31 July.

Marcelo Alonso, professor of theoretical physics at the University of Havana (Cuba), has received a 1-year appointment as scientific adviser in the Office of Science Development of the Pan American Union, Washington, D.C.

Harold B. Pierce, chairman of the department of biochemistry of the College of Medicine, University of Vermont, will retire at the end of the current academic year. He will be succeeded by **Donald B. Melville**, associate professor of biochemistry at the Medical College of Cornell University.

Jordan J. Markham, former director of the basic research programs in solid-state physics for the Zenith Radio Corp., Chicago, Ill., is now scientific adviser in physics research at Armour Research Foundation of Illinois Institute of Technology.

Feodor Lynen, of the Max Planck Institute for Cell Chemistry in Munich, Germany, will give the Karl Folkers lectures on 18, 19, and 21 April in the department of chemistry and chemical engineering of the University of Illinois, and on 25, 27, and 29 April in the department of chemistry at the University of Wisconsin. The series is sponsored by Merck and Co.

Hilger P. Jenkins, clinical professor of surgery in the College of Medicine of the University of Illinois, has been named professor of surgery at the University of Chicago.

Irvine H. Page, director of research for the Cleveland Clinic Foundation, has been appointed to membership on the Expert Advisory Panel of the World Health Organization.

A. J. Nicholson has retired as chief of the division of entomology of the Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia. **Douglas F. Waterhouse** has been named to succeed him.

J. A. Armstrong, a member of the scientific staff of the Medical Research Council at the National Institute for Medical Research, Mill Hill, England, will attend the International Congress of Anatomy in New York 11–16 April. He will visit in Boston and Washington before returning to England on 23 April.

Cornelius W. Pettinga, head of the biochemical research department of Eli Lilly and Co., has been named assistant to the vice president for research.

Katherine Esau, professor of botany at the University of California, Davis, is the first woman ever selected to deliver the Prather Lectures in biology at Harvard University. She will discuss the relations between plants, insects, and viruses on 12, 19, and 21 April.

Vladimir J. Glaser, senior staff member of the theoretical division of the Central European Laboratory of Nuclear Research, has been appointed professor of physics at the University of Maryland.

Harold G. Cassidy, professor of chemistry at Yale University, will discuss "Fission or fusion: The problem of the sciences and the humanities" at a number of colleges and universities, as a Sigma Xi national lecturer, from 19 April through 17 May.

Recent Deaths

George A. Edwards, Albany, N.Y.; 46; associate research scientist in micromorphology at the laboratories and research division of the New York State Department of Health; 1 Mar.

Lloyd C. Fogg, Newton Center, Mass.; 60; chief of laboratory at the Pondville State Cancer Hospital; former registrar and associate professor of histology and embryology at the Boston University School of Medicine; 28 Feb.

Louis O. Kunkel, Newton, Pa.; 75; plant pathologist; faculty member of the Rockefeller Institute from 1931 to 1949; did research on the relationship of viruses to plant diseases; 20 Mar.

Sheila S. Macintyre, Cincinnati, Ohio; 49; visiting associate professor of mathematics at the University of Cincinnati; faculty member of Aberdeen University (Scotland); 21 Mar.

Daniel A. McGinty, Detroit, Mich.; 63; laboratory director in physiology and endocrinology of Parke, Davis and Co.; 27 Jan.

Charles Oberling, Paris, France; 64; director of the Gustav-Roussy Institute for Cancer Research at Villejuif, France; dean of the medical faculty at the University of Teheran, 1939–47; author of *The Riddle of Cancer*; 11 Mar.

Book Reviews

American Research on Russia. Harold H. Fisher, Ed. Indiana University Press, Bloomington, 1959. xiv + 240 pp. $5.

How often one hears Americans complain, "Oh, but we know so little about Russia!" *American Research on Russia* tells how much we really *do* know about Russia, if people would only take the trouble to read even a small fraction of the studies referred to in this new survey. The book should be of interest to laymen as well as to experts.

American Research on Russia is a collection of 12 essays resulting from surveys conducted under the auspices of the Joint Committee on Slavic Studies of the American Council of Learned Societies and the Social Science Research Council; these surveys were widely discussed at the 10th anniversary conference of the Russian Research Center of Harvard University in January 1958. Far from being an anthology, the book is a most thorough guide to scholarly works on Russia which have been published in English during the last few decades, particularly since World War II. In addition to providing a general survey of the growth of Russian studies in the United States, the essays discuss the research in such diverse fields as history, economics, political science, philosophy and religion, social relations, science, geography, literature, linguistics, music, architecture, and the minor arts. Without attempting to prejudge the quality of individual research efforts, referred to individually or discussed in group topics, the essays attempt to assess the position of the community of American scholars in regard to an "integrated outlook in a study of Russian society." The verdict: a great deal has been done; much more needs to be done.

The survey shows that our research effort is represented by a community of some 550 scholars, approximately 450 major book and study titles, and an uncounted number of articles, monographs, reports, and so forth. Activities of the United States Government, as well as all "popular writing" on the U.S.S.R., are omitted from consideration in the essays.

Research, particularly during the last 15 years, has had a tendency to focus more and more attention on the examination of contemporary problems. The volume of research, and especially its quality, attests to the ability of the American academic community to withstand the pressures of America's shifting attitude toward communism and the U.S.S.R. The book makes a plea for more continued effort by appealing for wider public acceptance of, and acquaintance with, research on Russia carried out for the sake of scholarship and knowledge rather than for immediate utilitarian ends of a political or strategic nature. The broader understanding of "detached scholarship" is viewed as essential for bridging the gap that, unfortunately, continues to exist between "popular knowledge" of the Soviet Union and the wealth of scholarly research on Russia and world communism. This defense of the ivory tower is made with an eye toward the increasing role the government is expected to play in this area of research and in the hope of expanding the "pipeline" of private financial support.

Despite the tribute to "area-oriented interdisciplinary research," the very structure of the book, as well as most of the studies reviewed therein, mirrors quite accurately the true state of American studies on the Soviet Union, showing traditional discipline-oriented research to be the dominant activity. The departmental pattern of employment in colleges and universities and the discipline-oriented education of most Russian area specialists is responsible, in large measure, for this pattern. The majority of researchers teach their respective traditional disciplines, and only a few enjoy the luxury of research and teaching in Russian and Soviet areas exclusively.

Judging by the volume of research output, we find that historical research (with some 170 major titles) is the oldest and best established discipline. Postwar research advanced Soviet studies, particularly in political science (with some 70 major titles), social relations (about 70), and economics (about 50). As may be expected in these disciplines, there are many major studies, and some of them overlap onto closely related topics. By comparison, the score card for other fields is distressingly unfavorable, with far fewer titles of major scholarly works (for all other fields covered by the survey there are less than 100 titles). After the big four mentioned above come philosophy and religion, literature and music. There are very few studies in geography, the fine arts, or even linguistics. Titles are listed for only five major books on science in Russia. Most of these, and a supplement of two dozen or so articles, deal largely with ideological and political interference with Soviet scientific research. There is only one major study dealing with the institutional aspects of scientific research in the U.S.S.R. There are no major studies on the history of science. There are no major studies on engineering and technology. American science and Russian area studies will benefit mutually if more physical scientists and engineers can be attracted to study the Russian language, culture, and society, and to apply their scientific knowledge to area research. Soviet science and technology have remained terra incognita much too long.

NICHOLAS DEWITT
Harvard University and *National Academy of Sciences–National Research Council*

The Coconut Palm. K. P. V. Menon and K. M. Pandalai. Indian Central Coconut Committee, Ernakulam, South India, 1957. xvi + 384 pp. Illus. $11.95.

This monograph on the coconut palm is a well-documented and well-illustrated publication concerned with all aspects of the plant. Essentially it is a compilation from the literature published since the 1938 monograph, *The Coconut* (by J. S. Patel). The authors of this new

monograph are K. P. V. Menon, director of the Central Coconut Research Station, Kayangulam, and K. M. Pandalai, joint director of the Central Coconut Research Station, Kasaragod. In addition to the discussions of morphology, floral biology, and genetics and variation, there are descriptions of field culture, plantation management, pests and diseases, and the utilization of coconut products. The orientation is practical throughout, and, presumably, this was responsible for the curiously mixed and often outdated presentation in the strictly botanical chapters. The authors have merely repeated previously published works without due regard for their publication date or for the possibility of changing concepts in biology. Thus one finds anatomy discussed in terms of dermatogen, periblem, and plerome, while pollen formation is the result of "heterotypic" and "homoeotypic" divisions of chromosomes derived from a "spireme."

Once past these unpalatable botanical items, the book presents detailed descriptions of the practical aspects of coconut growing, including much tabular material, derived from the very extensive bibliography. Unfortunately there is a separate bibliography for each of the 18 chapters, but separate author and subject indexes are provided. The book should prove useful to those interested in economic aspects of botany and will be a very useful introduction to the literature on the coconut palm.

RICHARD W. HOLM
Department of Biological Sciences, Stanford University

America in the Antarctic to 1840. Philip I. Mitterling. University of Illinois Press, Urbana, 1959. 201 pp. Illus. $5.

Current research programs of the United States and other nations have revived interest in the history of antarctic exploration. A failing of several recently published histories is that they recount only exploration which has occurred since the late 1800's. The distant past and, sometimes, the very recent ventures are excluded. This book partially corrects the deficiency by dealing with a little known period of United States antarctic exploration (1776–1840).

America's first expeditions to the southern oceans were for commercial enterprise. Reports of fur seals in these waters circulated widely after Captain James Cook's voyage of 1775 and led to a number of reconnaissance voyages by different nations. *The States*, first known American sealing ship to sail the antarctic seas, shipped out of Boston to the Falkland Islands and took 13,000 pelts for later sale in China. The spectacular profit gave rise to a large industry, centered in Boston, Nantucket, and Stonington, which enjoyed financial success until 1793 when the market declined. After a lull, fur sealing was resumed and continued throughout the early 1800's.

Intense competition resulted in voyages of discovery among the subantarctic islands of the Scotia Arc, among offshore islands along the Antarctic Peninsula (also called Palmer Peninsula or Graham Land), and on the peninsula itself even though few new seal grounds were found.

Mitterling has summarized these voyages concisely, giving careful attention to conflicting claims of discovery made by Nathaniel Palmer, Christopher Burdick, George Powell, John Davis, Benjamin Morrell, and Edward Bransfield. Each of these men led a voyage from the United States or from Great Britain; claims by either country for discovery of Antarctica often cite their work. Palmer's meeting with the Russian, Bellingshausen, in January 1821 is also treated with care and insight. I believe Mitterling shows the difficulty of basing a claim of continental discovery on a single voyage made during this period. He says "Attempts to substantiate this imperfect evidence . . . have obscured [the sealers'] real accomplishments . . ."

By 1820 exploration financed by the sealing industry had become costly. Several suggested a nationally sponsored United States expedition, but, curiously enough, it was a theory expressed by John Symnes and his associate Jeremiah N. Reynolds which led to a national expedition. Symnes declared "the earth is hollow, habitable within; containing a number of concentric spheres, one within the other, and that it is hollow at the pole." Impassioned public pleas along with solicitations in Congress and the Navy Department eventually caused the government to send an expedition to Antarctica in 1838. Under the command of Charles Wilkes, the ships made a few discoveries in the area of the Antarctic Peninsula, then, in a second season, sighted the land now bearing Wilkes' name. Wilkes' discoveries left no doubt that there was a large southern continent, a fact substantiated a year later by Sir James Ross. Mitterling writes "When the United States Exploring Expedition put to sea, a precedent for the use of Federal funds to explore throughout the world was established . . . thus, American beginnings in Antarctica were conspicuous ones."

Philip Mitterling has chosen a fascinating and little known period of United States antarctic activity and has described it in a highly readable yet scholary manner. Because of these qualities the book will be of great value for some time.

PHILIP M. SMITH
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Tukani. Helmut Sick. Translated by R. H. Stevens. Eriksson-Taplinger, New York, 1960. 240 pp. Plates. $5.

This is the first detailed account of the famous Brazilian Roncador-Xingu Expedition, which devoted several years to blazing an 1800-mile route diagonally across Brazil from Rio de Janeiro to Manaus on the Amazon River. The author, a 50-year-old German-born naturalist, joined the expedition in 1946, and he ably describes the unknown lands through which the expedition passed.

Helmut Sick's sensitivity to the world of nature and to the problems of adjustment between civilized and primitive man makes this a valuable contribution to the historical and scientific record of one of the largest undeveloped regions in the world.

The title is taken from the name of a pet toucan that figures prominently in the book, but all living things captivate the author's alert mind. Sick discusses 10-inch stick insects, Indian women who feed water hogs at the breast and allow mice to build nests in their hair, exotic birds 1/15 the weight of a sparrow, stinging ants an inch long, lantern bugs glowing with luminous bacteria, and piping guans that play instrumental music with their wings when they mate.

One may doubt some statements, such as "[the natives] can pinpoint their position . . . [by] instinctive attributes with which many animals such as migratory birds and bees are endowed

by Nature." However, the book is full of hard-won information, and Sick's descriptions of the thunderous onslaught of the rainy season and of the daily and seasonal habits of the wildlife may be ranked among the classic passages of their kind. There is a useful glossary-index and 40 fine photographs.

Sick measures well the insect menace to health and the difficulty of preparing primitive peoples for civilization. In contrast to those who would roughhew half a continent with shorter vision, he favors the establishment of a large protective reserve that would "awaken the interest and admiration of the world."

EDWARD WEYER, JR.
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New York, New York

Nouveau traité de chimie minérale. vol. 16, group 7, *Fluor, chlore, brome, iode, astate, manganese, technetium, rhenium*. xxxix + 1195 pp. Illus. 1960. Paper, F. 170; cloth, F. 185. vol. 18, group 8, *Complexes du fer, du cobalt, et du nickel*. xxxix + 944 pp. Illus. 1959. Paper, F. 9500; cloth, 10,700. Paul Pascal, Ed. Masson, Paris.

Of the proposed 20-volume *Nouveau traité de chimie minérale*, ten volumes have appeared in print: volumes 1, 3, 4, 10, 11, 12, 14, 16, 18, and 19; and the following have been reviewed in *Science*: volumes 1 and 10 [**125**, 401 (1957)]; volume 3 [**128**, 138 (1958)]; volume 4 [**129**, 636 (1959)]; volumes 11 and 14 [**129**, 1355 (1959)].

Volume 16 covers the elements fluorine, chlorine, bromine, iodine, astatine, manganese, technetium, and rhenium. In volume 18 the complex compounds of iron, cobalt, and nickel are covered.

I have not seen volume 12, covering vanadium, niobium, tantalum, and protoactinium, nor volume 19, covering ruthenium, rhodium, palladium, osmium, iridium, and platinum.

The original intention was to complete the treatise between 1956 and 1960. The rate at which the individual volumes have been appearing indicates that the remaining volumes could be published fairly soon.

RALEIGH GILCHRIST
Division of Chemistry,
National Bureau of Standards

New Books

Advances in Carbohydrate Chemistry. vol. 14. Melville L. Wolfrom, Ed. Academic Press, New York, 1959. 537 pp. $15. Among the research areas covered are the amino sugars, the hemicelluloses, and the inositols; an obituary of Geza Zemplen is included.

Anatomy. Regional and applied. R. J. Last. Little, Brown, Boston, ed. 2, 1959. 457 pp. $15.

Anatomy and Physiology of Speech. Harold M. Kaplan. McGraw-Hill, New York, 1960. 374 pp. $8.50.

Advances in Veterinary Science. vol. 5. C. A. Brandly and E. L. Jungherr, Eds. Academic Press, New York, 1959. 461 pp. $14. Topics covered in this volume include eye examination and operations, Q fever, rabies, eradication of the tsetse fly in the Union of South Africa, theilerioses, and tissue culture in veterinary medical research.

Annual Review of Entomology. vol. 5. Edward A. Steinhaus and Ray F. Smith, Eds. Annual Reviews, Palo Alto, Calif., 1960. 458 pp. $7. Includes a cumulative chapter-titles index for vols. 1–5.

The Application of Genetics to Cotton Improvement. Sir Joseph Hutchinson. Cambridge Univ. Press, New York, 1959. 95 pp. $3.

Bananas. N. W. Simmonds. Longmans, Green, New York, 1959. 482 pp. 45s.

Beef Cattle. Roscoe R. Snapp and A. L. Neumann. Wiley, New York, ed. 5, 1960. $8.50.

British Veterinary Codex, Supplement, 1959. Published by the direction of the Council of Pharmaceutical Society of Great Britain. Pharmaceutical Press, London, 1959 (order from Rittenhouse Book Store, Philadelphia, Pa.). 152 pp. 35s.

Chemical Analysis. Herbert A. Laitinen. McGraw-Hill, New York, 1960. 625 pp. $12.50.

The Chemistry of Plant Gums and Mucilages. And some related polysaccharides. F. Smith and R. Montgomery. Reinhold, New York; Chapman and Hall, London, 1959. 637 pp. $18.

The Control of Growth and Form. A study of the epidermal cell in an insect. V. B. Wigglesworth. Cornell Univ. Press, Ithaca, N.Y., 1959. 147 pp. $3.

Data for Biochemical Research. R. M. C. Dawson, Daphne C. Elliott, W. H. Elliott, K. M. Jones. Oxford Univ. Press, New York, 1960. 312 pp. $10.10.

Design and Performance of Gas Turbine Power Plants. W. R. Hawthorne and W. T. Olson, Eds. Princeton Univ. Press, Princeton, N.J., 1960. 576 pp. $15.

The Education of the Scientist in a Free Society. Marquette Univ. Press, Milwaukee, Wis., 1959. 88 pp. Paper, $2.50. Papers delivered at a conference commemorating the 50th anniversary of the college.

Elements of Algebra. Howard Levi. Chelsea, New York, ed. 3, 1960. 172 pp.

Electrochemical Engineering. C. L. Mantell. McGraw-Hill, New York, ed. 4, 1960 (ed. 4 of *Industrial Electrochemistry*). 690 pp. $16.50.

The Foundations of Chemical Kinetics. Sidney W. Benson. McGraw-Hill, New York, 1960. 721 pp. $13.50.

Gestation. Claude A. Villee, Ed. Josiah Macy, Jr. Foundation, New York, 1959. 262 pp. $5.75.

Glutathione. Biochemical Society Symp. No. 17. E. M. Crook, Ed. Cambridge Univ. Press, New York, 1960. 116 pp. $4.50. Papers reviewing the chemistry of glutathione, techniques for its determination, interactions of glutathione in plant tissues, nerve tissues, human lens, and its bearing on radiation damage to living organisms.

A Guide-Book to Biochemistry. Kenneth Harrison. Cambridge Univ. Press, New York, 1959. 158 pp. Cloth, $3.50; paper, $1.95.

Historical Geology. Carl O. Dunbar. Wiley, New York, ed. 2, 1960. 511 pp. $7.95.

The Hydrogen Bond. George C. Pimentel and Aubrey L. McClellan. Freeman, San Francisco, Calif., 1960. 487 pp. Text edition, $9.50; trade edition, $11.40.

Hydrology. C. O. Wisler and E. F. Brater. Wiley, New York; Chapman and Hall, London, ed. 2, 1959. 422 pp. $9.25.

Introduction to Rubber Technology. Maurice Morton, Ed. Reinhold, New York; Chapman and Hall, London, 1959. 552 pp. $10.

The Manufacture of Sulfuric Acid. Werner W. Duecker and James R. West, Eds. Reinhold, New York; Chapman and Hall, London, 1959. 523 pp. $12.50

Masers. Microwave amplification and oscillation by stimulated emission. Gordon Troup. Methuen, London; Wiley, New York, 1959. 178 pp. $2.75.

Nature and Properties of Engineering Materials. Zbigniew D. Jastrzebski. Wiley, New York; Chapman and Hall, London, 1959. 588 pp. $11.

Nuclear Fuel Elements. Henry H. Hausner and James F. Schumar, Eds. Reinhold, New York; Chapman and Hall, London, 1959. 420 pp. $12.50. Proceedings of the First international symposium on nuclear fuel elements, held at Columbia University in January 1959.

Smithsonian Institution. *Annual Report*. 1958. Publ. 4354 (order from Supt. of Documents, GPO, Washington 25). 569 pp. $3.75.

Stress and Cellular Function. H. Laborit. Lippincott, Philadelphia, Pa., 1959, 266 pp. $7.50.

Structure Reports for 1952. vol. 16. A. J. C. Wilson, General Ed. Published for the International Union of Crystallography by Oosthoek's Uitgevers, Utrecht, Netherlands, 1959. 659 pp. $38.

Thermodynamics. Franklin P. Durham. Prentice-Hall, Englewood Cliffs, N.J., ed. 2, 1959. 359 pp. $6.25.

The Thunder of the Guns. A century of battleships. Donald Macintyre. Norton, New York, 1960. 352 pp. $3.95.

What Is Cybernetics? G. T. Guilbaud. Translated by Valerie MacKay. Criterion Books, New York, 1959. 134 pp. $3.50.

You and Science. Paul F. Brandwein *et al.* Harcourt, Brace, New York, ed. 3, 1960. 702 pp.

X-Ray Spectrochemical Analysis. L. S. Birks. Interscience, New York, 1959. 149 pp. $5.75.

Reports

Nature of the Hormonal Influence in Mouse Mammary Cancer

Abstract. New findings indicate that hormones may play a permissive role, rather than an inductive one, in mammary tumorigenesis. Hormones supporting normal gland development may result in the emergence of precancerous lesions; hormones maintaining such hyperplastic lesions may result in the emergence of tumors. The "inherited hormonal influence" may rest in genetically determined sensitivity of mammary tissue to somatotropin.

The relations of hormones to neoplastic disease continue to attract considerable attention. In hormone-regulated tissues, it is often considered axiomatic that hormones capable of inducing normal growth and function, or of stimulating excess growth and hyperactivity, are potential carcinogens by virtue of such capabilities. Among experimental materials, the hormone-controlled mammary gland of mice has been the most intensively investigated. From the pioneer studies of Leo Loeb and on through present-day researches, it has been accepted that estrogen is the prime hormonal inducer of mouse mammary cancer, although the importance of pituitary and adrenocortical factors is becoming increasingly recognized (*1–3*). Kirschbaum (*3*) has described estrogen as a carcinogen in the development of mouse mammary cancer, just as methylcholanthrene is considered to be a carcinogen.

The present discussion is based primarily on the work in this laboratory, where my co-workers and I have been engaged in an extended effort to determine the precise role of hormones in mouse mammary tumorigenesis. I do not intend to present our experimental data as such [these data were recently reviewed in part by DeOme *et al.* (*4*)], but rather to point out some conceptions of the well-established "hormonal influence" that may be pertinent to the experimental analysis of other instances of hormone-influenced tumorigenesis. Most of the issues considered herein have been raised as "problems" in this area by Clifton (*2*) in a recent useful review.

Where the existence of a definite precancerous state can be established, one can visualize hormonal participation in accelerating or delaying tumor formation as occurring on several possible levels: in the induction of the precancerous state, in the maintenance of the precancerous state, in the induction of the neoplastic state, and in the maintenance of the neoplastic state. In mouse mammary cancer, most tumors appear to be relatively independent of hormonal control ("autonomous"), although the growth rate of the tumor, once formed, may be influenced by hormones (see *5*). The hormonal combination necessary for the induction of a growth state need not be the same as that required for the maintenance of that state, and this distinction between *induction* and *maintenance* applies to normal, as well as abnormal, histogenesis.

The hormonal requirements for normal mammary gland development in one strain of mice (C3H/Crgl) have been well delineated by Nandi (*6*). Inasmuch as a tumor cannot arise in a nonexistent organ, the hormones required for normal mammary gland development can be considered as playing an essential role in eventual tumorigenesis. The gland must be sufficiently developed to allow the emergence of hyperplastic alveolar nodules (*7*); we consider it established that these are precancerous lesions (*8*). More than estrogen alone is involved, since estrogen induces neither normal development of any kind nor precancerous lesions in the absence of the hypophysis or hypophyseal factors. At present it appears that, in addition to estrogen, a hypophyseal factor (somatotropic or mammotropic) and a second steroid (luteoid or corticoid) are minimum requirements for the development of a normal inactive gland. It can be stated that, in a genetically tumor-susceptible, virus-infected mouse, the maintenance of this limited degree of mammary-gland development will result in the appearance of precancerous lesions (*9*). The specific hormonal milieu for noduligenesis then reduces to that necessary for development and maintenance of the normal gland. The actual inducer of the precancerous state may be elsewhere than in the hormonal background. A concentration of virus-like particles occurs in the precancerous nodules we have studied (*10*), and these particles are certainly a candidate for the role of definitive inducer of nodule formation.

In addition to the induction of nodules, another related hormonal effect lies in the ability to increase or decrease the incidence (rate of appearance) of such nodules and thereby to affect ultimate tumorigenesis. Data indicate that the hormonal milieux associated with pregnancy and lactation (*1, 11*), as well as administration of specific hormones, do indeed alter the incidence of nodules. Some hormonal treatments can increase the incidence of nodules even in a strain of mice wherein tumor incidence in virgins is normally high (*12*).

Hyperplastic alveolar nodules, once formed, can be maintained partially, maintained at a "normal" level, stimulated to secrete, or stimulated to lactate fully by various hormonal combinations (*9, 13*). Pituitary factors in the absence of ovary and adrenal have some nodule-maintaining ability (*9, 14*), and normal and hyperactive secretory patterns can be induced by combinations (a hypophyseal factor plus a corticoid) that are ineffective in the induction of nodules (*13*). Tumors generally arise in virus-infected mice where the mammary glands contain maintained nodules. Thus, the specific hormonal milieu for tumorigenesis may reduce to that necessary for maintenance of the hyperplastic nodules at a "proper" level, and again one may have to look elsewhere than at the hormonal factor for any specific inducer of the neoplastic transformation. The hormonal influence here, as in noduligenesis, may be a "permissive" or supportive one (see *15*), essential but not directly causative. Tumor development may conceivably be a secondary consequence of nodule maintenance—of sustained hyperplasia wherein the opportunity for new cell populations to develop and to survive is greater than normal. If one conceives of the tumor-cell population as occurring consequent to somatic mutation, certainly the opportunity for such changes is greater in a hyperplastic area. Survival of the altered cells could be facilitated by humoral factors from the proliferating cell population (see *16*).

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

As to the definitive role of estrogen in mammary tumor formation, it should be noted that in the development of the precancerous lesion, estrogen can no more be termed *the* noduligenic factor than can the pituitary hormone or the C-21 steroid. Synergism among the thee factors appears to be essential, and the specificity of the hypophyseal and of the adrenocortical factor is evidently relatively broad. Once nodules have been induced, æstrogen is not essential for nodule maintenance (*9*); furthermore, tumors have arisen from nodules in the absence of ovary and pituitary when only somatotropin and deoxycorticosterone are provided (*17, 18*). The central role classically ascribed to estrogen in mouse mammary tumorigenesis is thus open to serious question. Several different hormonal milieux for successful nodule maintenance and for the origin of tumors from such nodules are being delineated experimentally (*18*).

On the basis of the hormone dosage needed to induce lactation in hyperplastic alveolar nodules, it seems that there is a spectrum of sensitivity that is shown by different nodules and even occasionally by different regions of the same nodule. The nature of the correlation between hormone sensitivity and predisposition to neoplasia is presently being investigated, and the problem raises some interesting considerations. Is there a progression of sensitivity states in a nodule that leads from an almost normal requirement of hormones to a point where no hormones at all are required (presumably the state possessed by the tumor)? If this be true, there is an abrupt qualitative change from a point where a minute amount of hormone or hormones will result in a response of, and is required by, the hyperplastic cells to a point where no amount of hormone will result in response of the neoplastic cells—that is, where "autonomy" has been attained. Or is there a progressive loss of reactivity to hormones to a point reached by the tumor? If the latter assumption is correct, there should be an inverse correlation between the hormone sensitivity of nodules and their neoplastic potential.

Experiments have established the ability of bovine somatotropin to substitute for ovine mammotropin in inducing mammary differentiation and function, including lactation, in the C3H/Crgl mouse strain (*19*), and also in maintaining and stimulating hyperplastic nodules (*13*). The endogenous hormonal requirements for nodule formation and tumorous transformation appear to differ in different strains (*20*). Thus, in virus-bearing C3H/Crgl mice, nodule and tumor incidence is almost as great in virgins as it is in breeders. However, in the three virus-bearing A lines used in our laboratory, nodule and tumor incidence is almost zero in virgins, in contrast to a high incidence in breeders. In virgin C3H mice, the minimum combination, for nodule and tumor formation, of estrogen, corticoid, and somatotropin would normally be present. In virgin A mice, this minimum combination is presumably also present, but the mammary gland appears to be unresponsive. Further studies with various strains and sublines indicate that the A sublines are similar to other strains in their ability to develop mammary lobules and to lactate when properly treated with estrogen, progesterone, and mammotropin and subsequently with cortisol and mammotropin. However, the A sublines show no such response when the mammotropin is replaced by somatotropin, and herein may lie the fundamental genetic difference in the endocrine make-up between the A strain and a strain such as the C3H: the long-debated "inherited hormonal influence" appears to involve the genetically determined sensitivity of the target organ.

The material presented above may provide somewhat new perspectives in regard to the intervention of hormones in tumorigenesis in hormone-regulated tissues. The following general possibilities emerge from recent studies of mouse mammary cancer: (i) hormonal factors involved in the evolution of a definite precancerous state may be no more than those factors involved in normal tissue development; (ii) the tumorigenic role of the hormonal milieu may be no more than the continued maintenance of a degree of hyperplasia (the precancerous state); (iii) the so-called tumorigenic hormone may be but one component of an essential milieu wherein no one hormone can be considered more essential than any other; (iv) in general, the hormonal influence may be a "permissive" one, essential for tumor appearance but not itself inductive (*21*).

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Immunological Differentiation of Epididymal and Seminal Spermatozoa of the Rabbit

Abstract. Rabbit spermatozoa from the epididymis lack the antigenic material present on seminal spermatozoa, which these latter cells have in common with the seminal plasma. This observation provides further support for the indirect evidence, obtained previously, that antigenic material is taken up by the spermatozoa from the seminal plasma.

Mammalian seminal plasma is of highly complex composition (*1*). But little is known about the physiological significance of many of its components. Recently, immunological analysis has provided information suggesting that spermatozoa take up and firmly attach to themselves material from the secretions of the adnexal glands that constitute the seminal plasma. The seminal plasma and seminal spermatozoa of man and several mammals have immunologically specific components in common (*2–5*). Similar antigens are found in aqueous extracts of prostate and seminal vesicle, but not in extracts of testis and epididymis (*2, 4*). This, and the fact that azoospermic ejaculates of man contain the full complement of antigen (*2*), suggested that this material originates in the adnexal glands of the genital tract rather than in the testes. The following data provide direct evidence that this is indeed the case.

Rabbit semen was collected by means

of the artificial vagina (*6*). Seminal plasma and spermatozoa were separated by centrifugation at 12,800*g*. Epididymides of rabbits were removed from the animals immediately after exsanguination, and the spermatozoa were washed out of the dissected organs. Both kinds of spermatozoa were washed thrice in physiological saline solution, counted in a counting chamber, and suspended in physiological saline solution in the desired concentration. Complement fixation tests (Kolmer method) were made with these suspensions as antigens and the sera of guinea pigs immunized either with rabbit seminal plasma or with washed seminal spermatozoa. Controls with normal guinea pig serum and with immune serum from guinea pigs against whole rabbit serum remained entirely negative. Details on the techniques employed have been reported (*2, 4*).

The data obtained by this highly sensitive method show that epididymal spermatozoa lack the strongly antigenic material present in seminal spermatozoa and in seminal plasma (see Table 1).

These findings should not be interpreted as a denial of antigenicity of the spermatozoa as they originate in the testes. In fact, the data of Henle and his associates (*7*) and of Voisin (*8*) and Freund (*9*) show that testicular spermatozoa are not devoid of antigenic properties, and those of Pernot (*3, 5*) provide evidence that such antigenic properties can still be discerned in seminal spermatozoa. The point that concerns us here is that spermatozoa take up antigenic material from the seminal plasma before or at the time of ejaculation. It would be of interest to obtain information on the chemical nature of these antigens and their role, if any, in the physiology of reproduction (*10*).

Table 1. Fixation of complement by guinea pig immune serum (diluted 1/10) and antigen. The antiserum and antigen controls, also antigens plus normal guinea pig serum and antigens plus anti-rabbit serum immune serum, remained negative. ++++, No hemolysis; ++, moderate (about 50 percent) hemolysis; −, complete hemolysis.

Antigen dilution	Antiserum	
	Anti-spermatozoa	Anti-seminal plasma
Spermatozoa from semen (4 × 10^6 cells/ml)		
1/1	++++	++++
1/2	++++	++++
1/4	++++	++++
1/8	−	++
1/16	−	−
Spermatozoa from epididymis (4 × 10^6 cells/ml)		
1/1	−	−
1/2	−	−
1/4	−	−
1/8	−	−
1/16	−	−
Seminal plasma (diluted 1/1000)		
1/1	++++	++++
1/2	++++	++++
1/4	++++	++++
1/8	++++	++++
1/16	−	−

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Influence of pH on the Toxicity of Nitrogen Mustard

Abstract. The experiments reported here demonstrate the unexpected finding that, in mice, the *p*H of nitrogen mustard solution at the time it is injected into the animal appears to determine the toxicity of the material. At certain doses, highly acid solutions of nitrogen mustard show no toxic effects, while alkaline solutions at the same dose are invariably lethal. From further experiments on the antitumor activity of acid solutions of nitrogen mustard, it is concluded that the toxic effect is separable from the antitumor effect.

In the course of an investigation of the mechanism of toxicity of nitrogen mustard [methyl bis (β-chloroethyl)-amine·HCl; HN2] several facts have emerged: (i) toxicity can be prevented by the administration of any of several compounds before injection of the mustard (*1*); (ii) toxicity can largely be prevented in dogs by prior splenectomy and the administration of norepinephrine just before injection of HN2 (*2*); such protection is not conferred by splenectomy in mice (*3*); and (iii) intraperitoneal injections of mice with saline homogenates of spleen, mixed with nitrogen mustard, were uniformly more toxic than the same dose of nitrogen mustard alone (*4*). At the LD_{50} of nitrogen mustard (in saline), mixtures of mustard and spleen homogenates were uniformly lethal. The LD_{50} for HN2 in saline, in mice, is approximately 4.0 mg/kg, injected intraperitoneally (*5*).

In analyzing the data on the toxicity of mixtures of nitrogen mustard and spleen homogenates, it was apparent that the *p*H of the mixture was substantially higher than the *p*H of the mustard in saline alone. To control this discrepancy, Ringer's solution was substituted for the saline. When this was done, the *p*H's of the mixture of mustard and spleen homogenates and of the mustard in Ringer's solution were roughly the same, usually about 6.8. At this higher *p*H, the mustard was more toxic than it had been at the lower *p*H, and it was nearly as toxic as the mixtures of mustard and spleen homogenates. Therefore, a study of the effect of *p*H upon the toxicity of nitrogen mustard was started (*6*).

Male mice of the Swiss-Webster and C57Bl strains were used. All were healthy young animals maintained on a balanced ration with free access to food and water. Each animal was weighed just prior to injection, the dose of nitrogen mustard being based on its weight. At each *p*H, and for each dose, groups of 10 to 25 animals were used. To date, more than 3000 normal mice have been used in this toxicity study. For most of the work, intraperitoneal injections were used. For single doses 1.0 ml was given, and for fractionated daily doses the mustard was given in 0.5 ml of solution. In separate experiments the material was given intravenously in 0.2 ml of solution.

Nitrogen mustard (methyl bis (β-chloroethyl) amine·HCl; HN2), supplied commercially as Mustargen and diluted for injection (10.0 ml of saline or water per 10.0 mg of HN2) was found to have an initial *p*H of 4.7. When HN2 was diluted further for injection in mice, the *p*H of the material was usually about 5.2. To vary this *p*H, stock solutions of saline were made up with HCl or NaOH so that, upon addition to these solutions of HN2, a final *p*H of 2.0, 4.0, 6.0, 8.0, or 10.0 resulted. Several different doses of HN2 at each *p*H were used; through careful manipulation, the final *p*H's of the injected solutions within each *p*H group were quite close, in spite of tenfold differences in the concentration of HN2. All the solutions were injected within 60 seconds of mixing. An aliquot was taken, and the *p*H of each solution was measured thereafter in a Beckman model G *p*H meter.

Experiments were performed with doses of nitrogen mustard which ranged from 2.25 to 20.0 mg/kg, injected intraperitoneally as a single dose. In a few experiments the intraperitoneal dose was given as five consecutive daily injections, the total amounts ranging

Table 1. Percentage survival after single intraperitoneal injection of various doses of HN2 in strain C57B1 mice.

Survival (%) at various doses (mg/kg)				
3.0	5.0	7.5	10.0	20.0
		pH 2.2		
100	83	30	4	0
		pH 4.0		
92	0	0	0	0
		pH 5.2		
92	17	0		
		pH 7.2		
66	0			
		pH 8.9		
58				

from 5.0 to 9.0 mg/kg. In other groups doses of 3.0 to 4.0 mg/kg were given intravenously.

At every level at which it was tested, and regardless of the route by which it was given, nitrogen mustard was less toxic to mice at *p*H 2.0 than at any *p*H above this level. At low doses (2.25 to 2.75 mg/kg), deaths occurred only in animals that had received the material at *p*H 6.5 to 9.0. At high doses (7.5 to 10.0 mg/kg), only the animals that had received the material at *p*H 2.0 to 2.5 survived. Above 10.0 mg/kg, single doses of nitrogen mustard were lethal, regardless of *p*H. The dramatic effect of *p*H upon toxicity was more clearly seen at intermediate levels, in the range of 3.0 to 7.5 mg/kg.

Table 1 summarizes results in one experiment in which nitrogen mustard was given in a single injection at five different levels and five *p*H ranges. A dose of 3.0 mg/kg produced no deaths at *p*H 2.2 and deaths at *p*H 8.9 of nearly 50 percent. A dose of 5.0 mg/kg was lethal at *p*H 7.2, highly toxic at *p*H 5.2, and only slightly so at *p*H 2.2, with 83-percent survival at this low *p*H. At 7.5 mg/kg, which is above the accepted LD_{50} for mice, 30 percent of the animals that had received doses at *p*H 2.2 survived; there were no survivors at this dose at a higher *p*H.

The effect of hydrogen ion concentration upon toxicity is further illustrated in Fig. 1. It may be seen that with single doses of nitrogen mustard of 4.0 and 6.5 mg/kg there was little toxicity at *p*H 2.0, a substantial amount of toxicity at *p*H 5.0, and death in every case at *p*H 8.0 to 8.4.

Fractionation of the dose of nitrogen mustard decreased the toxicity of the material at the three *p*H ranges and two doses illustrated in Fig. 1. The pronounced effect of *p*H upon toxicity was again seen, and at total doses of HN2 of up to 8.75 mg/kg, no deaths were seen in groups that had received the material at *p*H 2.0. The same dose in a single injection, even at *p*H 2.0, was lethal for more than 75 percent of the injected animals. This dose (8.75 mg/kg) at *p*H 10, whether divided or given in a single injection, was invariably lethal.

With intravenous administration the striking effect of *p*H upon the toxicity of HN2, which had been repeatedly demonstrated with intraperitoneal injections, was again found. The toxic effects of nitrogen mustard were observed sooner after intravenous injection, and animals that had received 4.0 mg of HN2 per kilogram at *p*H 8.4 died within 3 to 4 days; with the same dose at *p*H 2.0 there were no deaths. With a dose of 4.0 mg/kg at *p*H 5.6, 40 percent of the injected mice died. With this dose of nitrogen mustard, given intraperitoneally to other mice (Fig. 1) there was the same range of toxicity, but with fewer deaths at high *p*H; deaths, when they occurred, came later with intraperitoneal injections than they did with intravenous injections. This finding is similar to many others that have been reported, which have shown that a dose of nitrogen mustard given intravenously is more toxic than the same dose given intraperitoneally (*5*).

The important effect of hydrogen ion concentration upon the toxicity of nitrogen mustard, which has been briefly described here and which was noted earlier by Boyland (*7*) is not easily understood. The body should be more than able to buffer the injected material. The possibility that the *p*H effect was peculiar to intraperitoneal injections, where buffering might be slow, was disproved by the finding that low *p*H has exactly the same protective effect against nitrogen mustard toxicity after intravenous injection.

In attempting to explain this phenomenon it was apparent that the entire sequence of chemical reactions of nitrogen mustard in vivo was affected by the *p*H at the time of injection, whether acid, neutral, or alkaline. The buffering action of blood was, although presumably almost instantaneous, insufficient to overcome this *p*H effect. Two possible explanations for the *p*H effect on nitrogen mustard toxicity are as follows. (i) Low *p*H prevents, and high *p*H induces, the rapid formation of toxic derivatives of nitrogen mustard in the solution of nitrogen mustard itself. Conversely, low *p*H may induce formation of a nontoxic mustard derivative. There are no data available to support this explanation. (ii) More probably, low *p*H prevents the formation, in vivo, of certain toxic products of the interaction of nitrogen mustard and some body constituent or constituents, while allowing the formation of other, nontoxic products. By contrast, high *p*H of injected mustard appears to change these reactions in the direction of formation of toxic product or products. This apparent mutability of the in vivo reactions of nitrogen mustard has significance in the elucidation of the mechanism of action of the drug. It was of great importance to determine whether such alterations affected the antitumor activity of nitrogen mustard.

The antitumor activity of highly acid

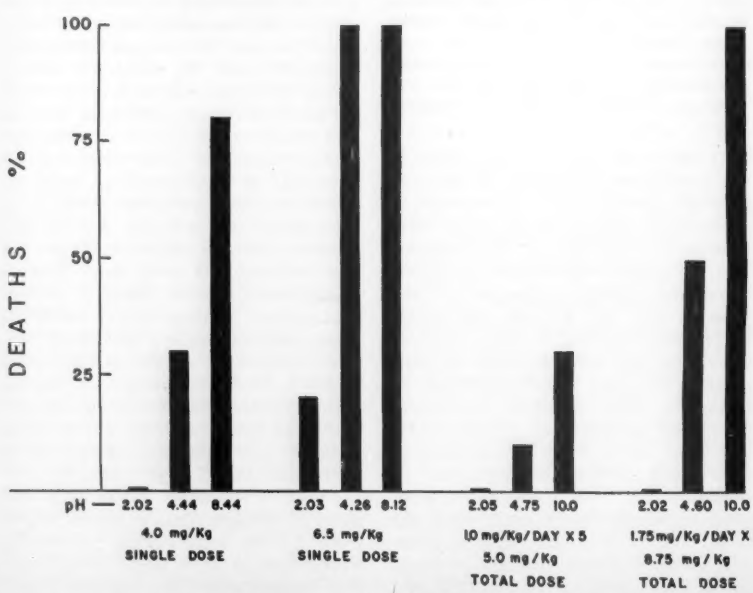

Fig. 1. Deaths in Swiss-Webster mice after single intraperitoneal doses of HN2 at various *p*H's, and after multiple daily doses of HN2, given intraperitoneally.

preparations of nitrogen mustard has been assayed in Swiss-Webster mice with Ehrlich ascites tumors. In repeated experiments, in each of which 300 mice were used, all untreated tumor-bearing animals died within 16 days (average 13.5 days), while mice that had received HN2 at *p*H 2 all lived more than 20 days, with average survival of 27 days, and some remain alive, without ascites, beyond that time.

It appears, therefore, that extremely low *p*H, while reducing the toxic effects of the nitrogen mustard in mice, does not interfere with the antitumor activity of the drug (*8*).

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Emphasis on Holotype (?)

Abstract. The description of new species should not be confined to physical description of a holotype. One specimen cannot include all characters or be typical of any taxon. The holotype serves only a nomenclatural function and might also be termed the name-bearer (nomenifer) to avoid confusion of "type specimen" with "typical specimen."

Shenefelt protests about vague, indefinite species descriptions, made ambiguous "deliberately," to cover a range of variation inherent in an abstract group concept (*1*). He says: "The purpose of a description is to convey a concept of the object under scrutiny as clearly as possible by means of words, pictures, or diagrams." He recommends that the holotype specimen be described relatively exactly and that the range of specific variation be discussed with reference to the holotype description. In this manner physical and abstract concepts would be differentiated more easily, and the functions of description would be served more effectively.

It is appropriate to protest about the quality of taxonomic descriptions in many fields of biology. Many taxonomic descriptions are poor for want of adequate concern about organization and content. Scientific authors seem to have difficulty in visualizing means of being helpful to readers. Shenefelt's emphasis on description of the physical holotype is not justified, however, from the standpoint of the basic objectives in taxonomy.

It has been emphasized repeatedly, for the benefit of plant taxonomists, at least, that the nomenclatural type (holotype) of a species is not to be confused or implicated in anyone's concept of what is "typical" for a taxon. A nomenclatural type is simply *the specimen*, or other element, with which a name is permanently associated. This element need not be "typical" in any sense; for organisms with a complicated life cycle, it is obvious that no single specimen could physically represent all the important characteristics, much less could it be taken to show many features near the mean of their range of variation. Consequently, an exact description of the holotype specimen leads us exactly nowhere in the process of discovering "modes," "means," or other "norms" typical of species.

Some approach to the problem of variation may be made by biometric analysis, and this information is pertinent for taxonomic description. However, descriptive matter is concerned *only* with more precise indication of the nature of the abstract group concept (species); this information has no bearing on, and never can have any essential relation to, selection or function of the nomenclatural holotype.

Often it has been noted that the term *type specimen*, in the sense of a nomenclatural type, is misleading because this "type" cannot be properly construed as being "typical." The terminology has been a source of misunderstanding, confusion, and misconception ever since the type "system" was introduced. The only function a nomenclatural type can serve is that of name-bearer. This function is perfectly mechanical in the technical manipulation of taxonomic nomenclature. Whatever may be said of its nomenclatural advantages, a discussion of the "type method" must always be phrased to avoid the misleading etymologic implications inherent in the term.

Perhaps if we were to speak of the name-bearer, or "nomenifer" method (L: *nomen*, name, + *ferre*, to bear), the proper implication would be more easily conveyed. Comprehension of the wholly arbitrary nature of the name-bearer specimen, however, is of the essence for understanding the meaning of "type method" in modern systematics. The term *type method*, usually properly used in the arbitrary sense, is now so entrenched in systematic literature that it would be most confusing to attempt to substitute any different term for it. However, if one wished especially to emphasize the name-bearing function, it might be permissible to insert the term *nomenifer* parenthetically, following the term *holotype* ["holotype (nomenifer)"] at the place where the type specimen is designated after a species description. Evidently, judged by frequent recurrence of the misconception, something of this nature sometimes is needed to signify that the type specimen is not necessarily typical in any particular.

The concept of the "typical" representative is frequently misused in biology. When the term is used, a question always can be raised regarding the nature of the measuring operation and the adequacy of sampling. If the term is used, it should be carefully qualified; commonly better meaning is conveyed by avoiding use of the term *typical* and stating definite facts, rather than by providing a "typical" interpretation. Pre-Darwinian "typology," with implications harking back to fixity of species and special creation, is frequently involved with a "typical" concept of "type." Emphasis on description of the holotype, rather than on the concept of a species population, does not seem likely to improve our means of classifying organisms or in understanding other essential aspects of biologic problems (*2*).

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14 December 1959

Histochemical Distribution of Succinic Dehydrogenase in Bone and Cartilage

Abstract. Large amounts of succinic dehydrogenase have been demonstrated histochemically in osteoclasts and chondroclasts. The same enzyme was also found in the giant cell of giant cell tumors of bone. This distribution suggests a relation to bone and cartilage resorption.

Many histochemical studies of bone formation and resorption have appeared in recent years. These studies are of great interest, since processes take place in areas separated only by a few microns, and this makes the analysis of biochemical data of even very small samples very difficult.

It has been shown histochemically

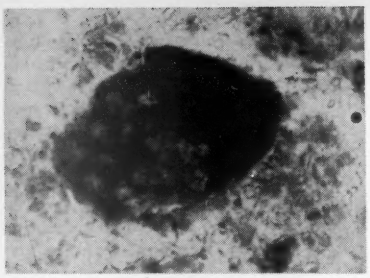

Fig. 1. Giant cell of a giant cell tumor of bone. The succinic dehydrogenase activity is localized especially in the cytoplasm (technique of Rosa and Velardo). (About × 347)

that osteoclasts and chondroclasts contain several enzymes the distribution of which follows a typical pattern. The distribution of alkaline phosphatase, acid phosphatase, esterases, aminopolipeptidase, beta-glucuronidase, and other enyzmes in bone tissues has been described by several authors (*1–4*). Tonna (*5*) has shown the distribution of succinic dehydrogenase in periosteum without describing in detail the cellular elements involved in the reaction.

We have studied the histochemical distribution of succinic dehydrogenase, using the technique of Rosa and Velardo (*6*). In this technique neotetrazolium chloride is used to show enzymatic activity in the presence of potassium cyanide. The study was made on endochondral and membranous growing areas of bone of 5-day-old C$_3$H/Ba rats, 5-day-old Wistar rats, and newborn human beings. Frozen sections (30 to 50 μ thick) without previous decalcification were used.

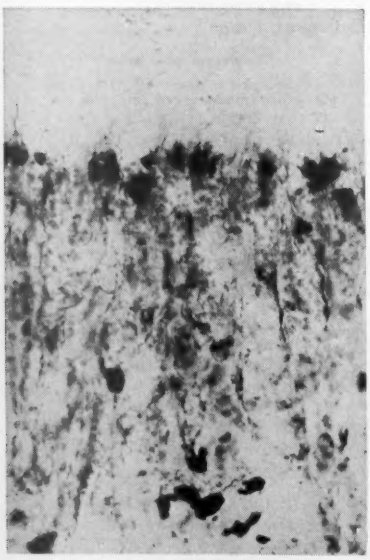

Fig. 2. Enchondral ossification of the growing zone of a human rib. The enzymatic activity is localized in the osteoclasts and chondroclasts (technique of Rosa and Velardo). (About × 104)

After incubation for a short period (5 to 15 minutes) an intense enzymatic reaction in the giant cells (osteoclasts and chondroclasts) involved in bone and cartilage resorption was apparent; the reaction was localized especially in the cytoplasm. After longer periods of incubation diformazan granules with a cytoplasmatic distribution appeared in almost all cartilaginous cells and in osteoblasts. The latter reaction was much weaker than that which took place in osteoclasts and chondroclasts. Still weaker was the reaction present in hypertrophic calcified cartilaginous cells. In three cases of giant cell tumors of bone, great enzymatic activity was observed in the giant cells characteristic of this tumor (see Figs. 1 and 2).

These results, together with the finding that other enzymes such as acid phosphatase (*2*), beta-glucuronidase (*4*), and aminopolipeptidase (*3*) were present in osteoclasts and chondroclasts, seem to confirm the hypothesis that these cells are not passive elements but cells with a high metabolic activity.

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10 November 1959

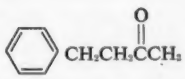
New Synthetic Lures for the Male Melon Fly

Abstract. Several *para*-substituted derivatives of 4-phenyl-2-butanone (I) have proved to be powerful attractants for the male melon fly (*Dacus cucurbitae*). These compounds, unlike anisylacetone, heretofore the best lure, attract even newly emerged flies. The most potent analog is 4-(*p*-acetoxyphenyl)-2-butanone (II), which also strongly attracts *Dacus ochrosiae* males.

Many insects depend on odors to guide them to a vital need—food, mate, host plant or animal, or oviposition site. Some odors evoke so compelling a response that the insect appears to have little choice but to seek out the source. The odors of some synthetics exhibit this action and are specific in that they attract only one or a few closely related species. Such lures have proved invaluable when used in traps for detecting infestations of harmful insects. Control or eradication measures can then most efficiently be applied only where, and as long as, insects are caught.

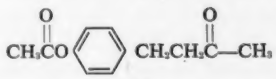
The use of anisylacetone as a lure for the male melon fly (*Dacus cucurbitae* Coq.) was reported in *Science* several years ago (*1*). However, its potency is not great, and it does not attract flies until after they attain sexual maturity—that is, 7 or more days (usually 10 or 11 days under field conditions in Hawaii) after emergence from pupation. A lure that attracts sexually immature males has an important advantage in that it enables the early detection of infestations so that control or eradication measures may be instituted before the insects have a chance to mate (*2*).

Our search for better lures has centered mainly around compounds related to anisylacetone, more specifically around derivatives of 4-phenyl-2-butanone (I).



I

These efforts were rewarded by the finding of a number of compounds that are not only more powerful and persistent but, more important, are also attractive to newly emerged male melon flies. The best of these materials is 4-(*p*-acetoxyphenyl)-2-butanone (II).



II

It was made by condensing acetone with *p*-hydroxybenzaldehyde in an alkaline medium by a procedure similar to that described by Drake and Allen (*3*), hydrogenating the product at 1800 lb/in.^{2} and 70°C with nickel kieselguhr catalyst, or by condensing phenol with 4-hydroxy-2-butanone according to Maki *et al.* (*4*), and acetylating; bp 123° to 124°C/0.2mm; n_D^{25} 1.5059. Theory for $C_{12}H_{14}O_3$: C, 69.99; H, 6.84. Found C, 69.38; H, 7.13.

Surprisingly, the ortho and meta isomers of II were practically ineffective.

In field tests candidate lures were each exposed in 10 Steiner plastic traps (*5*) which contained a lindane-chlordane mixture to assist in killing flies. One application of 2 gm of lure was made in each trap except for the

anisylacetone trap, in which 5 gm was applied. The best compounds and the total number of male melon flies caught in 61 days are given below:

4(*p*-Acetoxyphenyl)-2-butanone	30,752
4(*p*-Propionoxyphenyl)-2-butanone	22,985
4(*p*-Hydroxyphenyl)-2-butanone (*6*)	14,574
4(*p*-Butyroxyphenyl)-2-butanone	12,508
4(*p*-Isovaleroxyphenyl)-2-butanone	6,894
Anisylacetone	2,408

When used recently for survey purposes in the Mariana Islands, 4(*p*-acetoxyphenyl)-2-butanone proved to be very attractive to *Dacus ochrosiae* (Malloch) males.

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14 December 1959

Permeability Measurements of Castor-Bean Seed Indicative of Cold-Test Performance

Abstract. The conductivity and reducing-sugar content of water extracts of seeds were found to be correlated with stands produced under conditions favoring pre-emergence damping-off. Conductivity proved to be a rapid method of predicting relative differences in cold-test stands from lots of seed of the same variety.

Field stands of castor beans produced by different seed lots often reflect differences in quality not apparent from the percentage germination of the seed in a germinator, or from test weight, weight per number of seed, or appearance. I have used a cold test similar to the ones used for corn (*1*) to distinguish such differences, but such a test has the disadvantages of being time-consuming and difficult to standardize.

Reduced germination in a cold test has been shown to be due to various soil fungi, mainly *Pythium* spp., causing seed rot. Hottes and Huelson (*2*) and Tatum (*3*) suggested that materials leached from the seed serve as food that promotes the growth of fungi. They demonstrated a relation between seed permeability and germination or cold-test reaction by measuring the turbidity of seed steep water. Presley (*4*) reported that conductivity of distilled water leachings from cotton seeds at various stages of deterioration was a more rapid and accurate measure of seed viability than turbidity. Preliminary studies in this laboratory with castor bean indicated that water leachings from seed susceptible to rot contained sufficient sugar to promote fungus growth. The value and limitations of conductivity and reducing-sugar determinations of water extracts of castor-bean seed as a measure of susceptibility to seed-rotting fungi are described below.

In the first of these studies, seeds from the first, second, and third sequential sets of racemes were harvested at Beltsville, Md., from field plots of the varieties Cimarron, Dawn, Baker 296, Custer, and Cimarron hybrid. Clean, undamaged seeds from each raceme and variety and plot were subjected to permeability and cold tests. Three lots of 100 seed each were steeped in 200 ml of distilled water for 1 hour at 30°C. Electrical resistance of the steep water was determined with a Serfass conductivity bridge, with 60-cycle current. For reducing-sugar determinations, three lots of 100 seed each were steeped in 50 ml of distilled water for 1 hour at 30°C. Relative differences in reducing-sugar content were estimated by the color developed when tubes containing 5 ml of steep water and 2.5 ml of Benedict's solution were heated in boiling water for 5 minutes. More precise determinations were made on some lots by the methods of Hawkins and Van Slyke and of Munson and Walker, as given by Hawk (*5*). Chromatographic analysis of sugars was made on water extracts from certain lots. In the cold test, 25 seeds from each lot were planted in naturally infested composted soil in each of four 1-qt cans. The soil was watered to field capacity. Cans were held at 10°C for 10 days and then at 20°C for 21 days.

Table 1. Relation of electrical resistance of seed steep water to cold-test reaction.

Variety	No. of lots	Resistance range (ohm/cm)	Stand range (%)	Correlation coefficient
		Experimental lots		
Baker 296	8	2400–1500	84–50	.93*
Cimarron	8	8700–1100	39– 8	.95*
Dawn	6	5300–1300	78– 5	.97*
Custer	5	3200–2000	72–44	.88†
		Commercial lots		
Baker 296	24	3100–1285	49– 7	.92*
Baker 296	29	3142–1337	32– 5	.94*‡

* Significant at .01. † Significant at .05. ‡ Partial correlation with weight per 100 seed; the linear correlation coefficient (weight per 100 seed not considered) was .86 (significant at .01).

Seed lots of each variety could be ranked as good, intermediate, or poor on the basis of color developed in the test with Benedict's solution. This reducing-sugar test was negative on water extracts from seed that produced the highest stands in the cold test. Steep water from the seeds of poorest quality gave a strong test and was found to contain as much as 0.1 percent of reducing sugar. Chromatograms showed both glucose and fructose to be present, with the latter predominant. A trace of sucrose was present in an extract from seed of extremely poor quality. Quantitative estimates of reducing sugar that were made from the chromatograms agreed with those obtained by the chemical methods. No arabinose, xylose, maltose, or ribose was detected.

Conductivity proved more rapid and precise than sugar determinations for predicting the relative performance of lots within a variety. Highly significant positive correlation coefficients (Table 1) were found within most varieties for the relation of electrical resistance readings and stands in the cold test. To make intervarietal comparison of seed lots did not appear possible.

In a second set of experiments, conductivity measurements were made on water extracts of seeds of 200 lots of the variety Baker 296 from commercial fields near Plainview, Tex. Seed weight also was determined from two 100-seed samples from each lot. Twenty-four seed lots, selected for a range of electrical resistance values, were tested simultaneously for cold-test reaction. Subsequently 29 similar lots, selected for a wider range of seed weights, were subjected to the cold test. Conductivity and cold-test procedures were the same as described above.

Highly significant correlation coefficients (Table 1) were found for the relation of electrical resistance and stand in the cold test. In the 29 commercial seed lots selected for a range of seed weights the correlation coefficient was higher when weight per 100 seeds was used as a third variable in partial correlation. Percent stands (*Y*)

expected from these seed lots in the cold test could be predicted, with an accuracy of ± 8.5 at the 5-percent level, from electrical resistance (X_1) and weight per 100 seed (X_2) by the equation:

$$Y = -267.8966 + 0.0169\,X_1 + 9.3321\,X_2.$$

These experiments indicate that conductivity of seed steep water, presumably a measure of seed permeability, is correlated closely with stand in the cold test. The amount of reducing sugar present also appears to be closely associated with stand. The cold test, as performed with a 10-day incubation at 10°C, probably accentuates loss of stand due to permeability. Stands under less adverse conditions of temperature and moisture may be more closely associated with the amount of sugar or other substances present on the seed-coat surface than with the amount which may leach from the seed in water in a given period of time (*6*).

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14 December 1959

Auditory Thresholds in the Rat Measured by an Operant Technique

Abstract. An adaptation of the Ratliff and Blough technique has been developed for auditory measurement in rats. Thresholds for a 2000-cy/sec tone were determined over a period of weeks. Kanamycin, an ototoxic agent, was then administered, and the gradual rise in threshold was followed.

We have applied the Békésy (*1*) method of automatic audiometry for human subjects (a modified method of adjustment) to the measurement of auditory thresholds in rats, following the lead of Ratliff and Blough (*2*), who adapted it for the determination of visual thresholds in pigeons. The essence of the method is that the subject himself controls the stimulus, and his behavior is at the same time controlled by the stimulus. With the Békésy audiometer, this control is accomplished by instructing the subject to hold down a button, actuating an automatic attenuator, so long as he hears the sound. While he holds down the button, the sound is gradually attenuated. When the intensity is reduced below his threshold of hearing, he releases the button, and the intensity is automatically increased.

The rat is trained by operant techniques (*3*) to press one bar repeatedly so long as he hears the sound, and to press a second bar when he does not hear it. Responses on the first bar lower the sound intensity, while those on the second bar raise it again. An appropriate schedule of reinforcement with water keeps the thirsty rat working for about an hour (*4*).

The rat works in a small wire cage, mounted in a sound-treated, ventilated wooden box. Two stainless-steel bars, each controlling a microswitch, are placed at the front of the cage, facing a loud-speaker. A motor-driven dipper delivers 0.02 ml of water per reinforcement. The programing is arranged so that presses on bar *A* reduce the sound intensity and then turn the sound off by means of an electronic switch. Presses on bar *B* bring a reinforcement with the dipper and then turn the sound on again at the attenuated level. A block diagram of the equipment is shown in Fig. 1.

Male albino rats weighing approximately 250 gm were allowed access to water for only ½ hr/day for 2 weeks. After this period of deprivation, each rat was placed in the testing box, which contained a single bar (*B*) and a dipper under manual control. The rat was trained to press the bar under continuous reinforcement. This schedule was gradually changed until stable rates were obtained on a variable-ratio (VR) schedule. At this time a second bar (*A*) was introduced into the test box, and a 2000-cy/sec tone was turned on at a moderate intensity (about 60 db SPL). The rat was then trained to press bar *A* once in the presence of the tone in order to turn it off, before he could obtain a reinforcement on bar *B* with the VR8 schedule. After reinforcement, the tone came on again. The schedule on bar *A* was gradually changed to VR8, so that the rat had to press bar *A* several times before the tone went off and then had to switch to bar *B* and press several times to get a reinforcement.

The following contingencies were introduced during the two-bar training to insure that the animal was responding to the auditory stimulus. (i) With the tone off, three presses on bar *A* turned the tone on again. (ii) After a reinforcement, the tone remained off 20 percent of the time, and the rat could

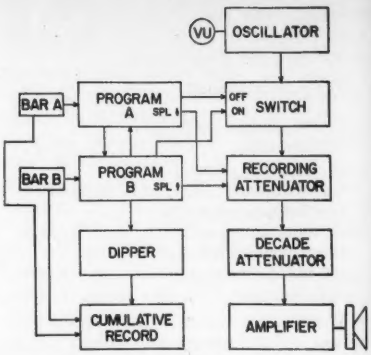

Fig. 1. Block diagram of auditory and programing apparatus.

secure two consecutive reinforcements on bar *B*. (iii) Presses on bar *A* were erased if the rat switched to bar *B* without turning the tone off. (iv) Time out (10 sec) followed continuous overpressing of bar *A*. The training under fixed SPL conditions was continued until a stable discrimination was obtained.

During threshold testing the programing was altered. A random number of presses on bar *A* reduced the sound level in 5-db steps, attenuating it 5 to 20 db before the sound was turned off. When the sound was off, a random number of presses on bar *B* gave a reinforcement and turned the sound on again at the attenuated level. Further presses on bar *B* (three presses) with the sound on increased the intensity again in 5-db steps.

In the course of pressing bar *A* the rat reached a point where his presses had reduced the intensity to a level below his threshold but had not turned the tone off. At this time he switched to bar *B*, since for him the two conditions, tone off and tone below threshold, were equivalent. By pressing bar *B* a number of times, he drove the intensity above his threshold and must then switch back to bar *A* to turn the tone off. These oscillations in intensity

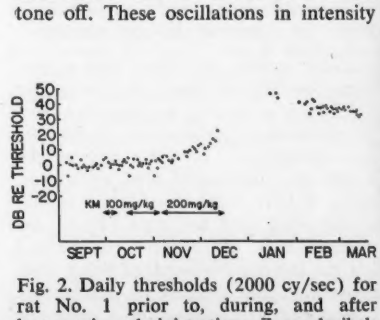

Fig. 2. Daily thresholds (2000 cy/sec) for rat No. 1 prior to, during, and after kanamycin administration. Zero decibels represents the average threshold during the 20-day control period, that is, 44 db sound pressure level (SPL).

above and below his threshold of hearing were registered by the recording attenuator. To estimate the threshold intensity, the reversal points were read from the chart and their arithmetical mean was calculated.

The programing on bar *A* was arranged so that presses on bar *A* attenuated and occasionally turned the tone off, allowing the rat to secure reinforcement by pressing bar *B*. In this way the rat was sufficiently rewarded during threshold testing and would work for approximately 1 hour at a high and steady rate, during which 200 or so reversals of intensity levels were obtained.

Since we were interested in the possibility of using the method for tracing the gradual development of hearing impairment produced by ototoxic antibiotics, we first tested its reliability by measuring daily thresholds for a 2000-cy/sec tone in four male rats for 20 to 44 days. For each daily threshold the arithmetical mean of 150 or more reversal points was calculated from the daily record. The day-to-day consistency of each rat's performance was good, with only 9 to 15 percent of the daily thresholds for a given animal falling outside a ±5-db range. Agreement of the findings for the four rats was also satisfactory; the mean daily thresholds for the four animals ranged from 37 to 47 db SPL during the control period. We are not prepared, however, to state that these values represent absolute thresholds, since we do not yet know how much masking noise was present in the box as a result of the rat's own activity.

Kanamycin (*5*) (100 mg/kg) was given daily to rats Nos. 1 and 2 for 37 days with a 6-day interruption. The dose was then increased to 200 mg/kg and administered for an additional period of 40 days. Rats Nos. 3 and 4 received, respectively, 48 and 41 daily injections of 400 mg/kg.

The daily thresholds for rat No. 1 are shown in Fig. 2. During the administration of 100 mg of kanamycin per kilogram no threshold shift occurred. A gradual rise in threshold appeared when the dose was increased to 200 mg of kanamycin per kilogram.

The body weight of rat No. 1 decreased steadily during the time that he received kanamycin. This weight loss was attributed to a disturbance of water balance resulting from the well-known nephrotoxic effect of the antibiotic (*6*). It became necessary to interrupt the threshold measurements and to give him free access to water for 2½ weeks. One and a half weeks elapsed before the animal produced reliable records again. The thresholds were then approximately 35 db higher than those recorded prior to administration of the drug.

Rat No. 2, which was given the same doses as rat No. 1, showed a maximum hearing loss of 20 db and quickly recovered part of this loss, which became stabilized at approximately 10 db.

The thresholds for rats Nos. 3 and 4, which were given 400 mg of kanamycin per kilogram, remained stable during the first 20 days of kanamycin administration. Thereafter, the threshold for rat No. 4 began to rise. Because of weight loss he was given free access to water for a week. Eventually he produced acceptable records, showing a 55-db rise in threshold.

Rat No. 3, on the other hand, produced no reliable threshold records after kanamycin treatment was stopped. He was then placed under "training" conditions, during which time he was unable to discriminate tone-on from tone-off, even when the tone was presented at an intensity of 116 db. Like some patients who have received kanamycin, his loss of hearing was apparently complete (*7*).

The results show that this method can be used to follow the gradual development of hearing impairment produced by an ototoxic agent in rats. We believe that it is equally adaptable to the measurement of absolute thresholds, provided the masking noise produced by the rats' bar-pressing activity is minimized by providing quiet bars (*8*).

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2 December 1959

Persistence of Alkaloids in Plant Tissue

Abstract. Under appropriate conditions of preservation, alkaloids can be detected in plant tissues after extended periods of time. A positive test for this class of compounds was given by a sample of plant material estimated to be 1300 years old.

The many changes which can take place in plant tissues during drying and preservation of specimens makes it of more than passing interest when certain chemical components of the plants can be recognized after long periods of storage. Webb (*1*) noted the presence of alkaloids in herbarium specimens 10 to more than 50 years old, and in one extreme case a strong positive test for alkaloids was obtained on a sample of *Acronychia baueri* collected in 1824.

Recent archeological investigations of the remains of northern Arizona cave dwellers turned up a number of small fiber-bound bundles of plants presumably used as medicinals. The bundles were found in a context which indicates that they were collected about A.D. 650. The state of preservation of the bundles and other associated materials indicates that the caves have been completely dry since that time. The contents of the bundles gave a positive, albeit weak, test for the presence of alkaloids (*2*), and at least one of the several plants included in the packets has been identified as *Nicotiana attenuata* (*3*), a wild tobacco which still grows in the area.

This is not to suggest that the positive alkaloid test is necessarily due to nicotine or its relatives; no attempt has yet been made to identify the substance or substances giving the positive test. But it is remarkable that these compounds have persisted in the plant tissues over a period of about 1300 years.

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2. The chemical tests were carried out by I. J. Pachter, of Smith Kline and French Laboratories.
3. The identification was made by Volney H. Jones, ethnobotanist, Museum of Anthropology, University of Michigan. A detailed report on the occurrence and significance of the tobacco is being prepared by Jones and Morris.

3 November 1959

Letters

(Continued from page 1010)

review and says that the editors of *Science* should "insist on the same objectivity in presentation of the position of the Catholic Church that they would on any strictly scientific matter."

O'Loane then proceeds to draw a fine legalistic type of distinction between the actions and views of the Catholic Church that are backed up by a "doctrinal stand" and those that are not. He tells us that the Catholic Church has taken no doctrinal stand on birth control and cites as a parallel case the dispute over an earth-centered versus a sun-centered solar system. He says that no doctrinal stand was taken on either of these matters, and he therefore implies that discussion of either of these matters is irrelevant. Apparently it is also irrelevant that Galileo was condemned for his views, that his sentence was ratified by the Pope, and that his works were placed on the *Index*, where they remained for 200 years. Is a victim of an undeclared war any less dead than the victim of a declared war?

In contrast, the doctrine of the Assumption is cited as an infallible article of doctrine because of the statement of the Pope on 1 November, 1950. Therefore scientist O'Loane must be certain that the Virgin Mary ascended bodily to heaven, flesh, skin, bones, hair, toenails, and all.

The only way a scientist can accommodate this sort of thinking is to have a bicompartmented mind—one compartment for logical reasoning, the other compartment for matters of faith. In a scientific discussion logic is not allowed to enter the sphere of faith, or at least is allowed to enter only on a subordinate basis. That is why the Catholic logician is always subordinate to the Catholic theologian. The theologian is the dogma-maker, and the logician fits his logic to the dogma, or if he can't make it fit, he is required to suspend judgment.

A scientist who discards scientific objectivity as soon as the thought process arrives in the forbidden area of dogma and doctrine is only a part-time scientist. Indeed it would be more wholesome if such a scientist would base himself squarely on faith and make no pretense to a scientific apology for doctrinal belief.

As to the tremendous import of the population bomb, which is the essential message of Sulloway's book, I would that some Amos or Isaiah could wake up the sleeping minds of our Catholic brethren.

ALAN RHODES
R.D. 1, Eagle Road, Willoughby, Ohio

In my earlier letter (p. 1364) I said: "The Catholic Church . . . believes the end does not justify the means, and the use of bad means for a good end makes [an] act morally bad . . . the means, artificial birth control, are always wrong." Apparently it was not clear to some that this is equivalent to saying that it is a *doctrine* of the Catholic Church that artificial birth control is always morally wrong. My reply will be confined to attempting to clear up some errors of fact and to answering the charge of "the dual intellectual attitude of the Catholic scientist."

When a married couple wishes to limit the number of their children, there are, omitting any consideration of sterilization, four methods they can use: they can (i) refrain from using their marital rights; (ii) make use of their marital rights in the proper manner, but at a time when conception cannot normally take place; (iii) make use of some method of artificial birth control; (iv) resort to abortion.

The term *proper manner* means that the marital act is performed so that the male organ deposits semen in the vagina of the female. The term *artificial birth control* means interference with the proper manner of performing the marital act by withdrawal or by some chemical, mechanical, or other artificial means designed to prevent conception.

Regarding the four methods of limiting the size of the family the doctrine of the Catholic Church is as follows: (i) abstinence is permissible under certain circumstances; (ii) marital rights may, under certain circumstances, be used in the proper manner at a time when conception cannot normally take place; (iii) artificial birth control is *always* morally wrong; (iv) therapeutic abortion is regarded as murder.

Methods (ii) and (iii) are both means for separating intercourse and parenthood. Intercourse and parenthood are also separated when the partners are sterile by virtue either of natural defect or of age. Sulloway is undoubtedly correct in saying there were Catholic *authors* who, as Davis (*1*) puts it, "attributed . . . dire consequences to the separation of intercourse and parenthood." From this Davis and Sulloway erroneously concluded that the Catholic *Church* had taken a stand against the "separation of intercourse and parenthood." Sulloway did not (and cannot) prove this.

Apparently Sulloway fell into this error because he did not understand the relationship between what a Catholic writer may say and what the Church teaches. Since Catholic authors can be on either or both sides of a disputed question, one must not attribute to the Church the views of some particular author. This error is, unfortunately, quite common among non-Catholics and formed the basis for a considerable number of additional errors made by an Episcopalian bishop in a recent issue of *Life* magazine.

This was why I used the dual illustration of the Copernican theory and the dogma of the Assumption. The first illustrates the case in which, although Catholic writers were on both sides of a question for many decades, the Church took no doctrinal stand. This was obviously not parallel to the case of birth control.

Copernicus (*2*), who died some 20 years before Galileo was born, was one of a growing number of churchmen-scientists who realized that the idea, then current among theologians, that the Bible gave detailed information on astronomy and geology was wrong. James B. Conant (*3*) has pointed out that a new scientific idea takes hold slowly even among scientists. So it was in this case. Eventually it was realized that Copernicus was correct in his scientific theory and in the idea, not original with him, as to the relation of the Bible and astronomy.

The Church never took a doctrinal stand one way or the other. It took *disciplinary* action against Galileo—he was never tortured—because he violated a gentleman's agreement of 1616 which allowed him to teach Copernicus' theory as a scientific hypothesis but not as a fact (*4*).

The second example, that of the doctrine of the Assumption, illustrates a dispute concerning an apostolic tradition commonly accepted by the Eastern Orthodox and Catholic churches for many centuries (*5*) but not formally defined as a doctrine. Since it was not formally defined, further discussion was permissible, and Catholic writers were found on both sides until the Church finally crystallized its stand in an irrevocable doctrinal decision in 1950.

With respect to the position of the Church on separation of intercourse and parenthood, the facts are that it has repeatedly condemned method (iii), artificial birth control, but never method (ii).

In 1823 the Sacred Penitentiary declared the prevention of conception by artificial means contrary to the natural moral law. In 1851 the Holy Office said that the onanistic use (Gen. 38: 9) of marriage was opposed to the natural moral law (*6*). The latest condemnation is that quoted by Hoffman from Pius XI's encyclical on "Christian Marriage."

The legitimacy of the so-called rhythm method is mentioned in the same encyclical: "Nor are those con-

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Metallography and other matters

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Just issued is a new one, "Photomicrography of Metals." It contains 13 pages on the metallographic microscope (unbiased toward any particular make of instrument, since we are not in that business), 3 pages on illumination, 5 on filters, 3 on photographic materials (which we do make), 5 on exposure determination, and 8 on processing and printing—just enough for thoughtful perusal between the evening paper and the 11 o'clock news. The pages are meaty; the illustrations are there to explain, not just fill space; the author (anonymous) is a photomicrographer, not an ad-writing hack.

Also just published is the 8th edition of one that has taught many thousands of people since 1933 the rock-bottom facts about the photographic emulsion as a scientific device. The title, "Kodak Photographic Films & Plates for Scientific and Technical Use," dissembles a wee bit. In the old days astronomy was regarded as too thin and unworldly a market to justify commercial literature; therefore the title was devised as a shield from the beady eyes of hard-headed accountants. They find it hard to understand that addressing ourselves to the needs of men with their minds inside stars strengthens the capabilities of photographic technology in general. Indeed, this new 8th edition contains some helpful hints from Mount Wilson and Palomar Observatories that could teach an amateur astronomer to think like a pro. The edition reveals some constriction from the sprawling diversity of *Kodak "Spectroscopic" Plates and Films* hitherto offered, and these pages show how the present lineup fills the bill.

Theoretically the purchase of these data books from your Kodak dealer draws him and you closer together. Those willing to forego the personal touch can obtain them from Special Sensitized Products Division, Eastman Kodak Company, Rochester 4, N. Y., which is also the place to address specific questions.

Man passing out dotriacontane

We have a yarn that ties in the sperm whale with relativity. It has a moral but lacks a punchy climax.

On the theory that not only is the grass greener on the other fellow's lawn but he also leads a more interesting life, we would tell the organic chemists how the atomic physicists are looking for substances against which polarized free electrons can bounce without having their spins inverted. The physicists want to coat a substance like that on the walls of evacuated glass vessels. It should have no free or unpaired electrons, no crystal structure. To an electron scooting by, such a molecule should appear magnetically inert. The small residual pressure tolerable in the vessel should be mostly of rubidium vapor and not of the non-inverting substance. Also the coating must have good transmittance at around the 8000A wavelength of the radiation fed to excite the rubidium.

"Optical pumping," the theme these experiments share, has to do with the manipulation of quantum levels so that emission from the excited alkali metal atoms can be tuned with great elegance. Pressure to improve understanding of the phenomena comes from the need for instrumentation to study the Van Allen radiation belts and for satellite-borne atomic clocks to check out Einstein's old predictions about the meaning of time as told from a moving timepiece.

On the same greener grass theory, the yarn as spun for atomic physicists would focus on some little samples of non-inverting substance that were passed out at a recent optical pumping conference by a man who may well have bought the material from us as *Dotriacontane* (Eastman 3555). Now the sperm whale enters. Spermacetti wax once had a role in physics as the material of the standard candle which defined candlepower. When chemists attacked it, they found cetyl palmitate, $C_{16}H_{33}OCOC_{15}H_{31}$. We have to make a long, uniform, inert, homogeneous molecule out of that. First we snap off the $-OCOC_{15}H_{31}$ and replace it with bromine. Then, making use of a thought that occurred to Adolphe Wurtz around 1855, we react the cetyl bromide [which we call *1-Bromohexadecane* (Eastman 3375)] with sodium.

$$C_{16}H_{33}\boxed{Br + 2Na + Br}H_{33}C_{16} \rightarrow C_{32}H_{66} + 2NaBr$$

In effect, the two oxygens the whale put in the middle of the molecule have been replaced by hydrogens. That is *Dotriacontane*.

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sidered as acting against nature who in the married state use their right in the proper manner, although on account of natural reasons either *of time* or of natural defects, new life cannot be brought forth" (italics added) (*7*). Because, as I said in my earlier letter, the Church had never condemned the separation of intercourse and parenthood, no shift in its position was necessary when the rhythm method became known. Davis' and Sulloway's allegation that the Church shifted its position is but another of their many errors.

Although Hoffman wrongly understood his quotation from the encyclical as condemning the separation of intercourse and parenthood, and although he is also mistaken in thinking that the encyclical satisfies the conditions for an ex cathedra pronouncement (*8*), he is correct in concluding that the condemnation of artificial birth control has a doctrinal basis in the Catholic Church.

There remains the question of whether, as Sulloway, Davis, and Calingaert hope, the Catholic Church will change its opinion, even if it takes a few centuries to do so. This hope has been expressed repeatedly in the past several years by members of the Planned Parenthood Federation, various demographers, and even Protestant clergymen, who, in some cases, have asserted that the Catholic Church must or will change its mind. Perhaps the worst feature of Sulloway's very unfortunate book (*9*) will be its effect in helping to foster this delusion.

This vain hope arises because these critics do not understand that the Church's ban on artificial birth control is not a disciplinary matter, as are, for example, Friday abstinence, the observance of Sunday instead of the Sabbath, and the celibacy of the clergy. In the case of birth control the Church is interpreting both the natural moral law and Sacred Scripture. When she does this, she acts only as a teacher, not as a lawmaker. Since God, not the Church, is the author of the law, the Church cannot change it.

As I said previously, "an *essential* claim of the Catholic Church is that when it *does* take a definite doctrinal stand it cannot be in error." The Catholic Church would collapse if it ever changed in essence one of its doctrines. However, "over a period of 20 centuries the Church has never made an essential change in any of its doctrines," and it never will.

Since the purpose of the first letter was to correct serious misstatements appearing in a review, it was not *ad rem* to discuss the problem of control of population. However, since Calingaert and Rhodes have mentioned it, I shall make just two remarks. If there is a population control problem in some parts of the world, the duty of the individual Catholic is not solved by pointing out the moral law. Catholics, as well as others, are bound to aid in its solution by using all *moral* means (*10*).

It is not surprising that Calingaert and Rhodes, having missed the main points of my letter, should be in difficulty in assessing the situation where other, more subtle, factors, such as evaluation of the intellectual attitude of a whole age, are involved. Passing over their various fantasies and implications, unwarranted either in logic or fact, I come to the problem of the supposed dual intellectual attitude of the Catholic scientist.

In the short space of a letter to the editor all I can hope to do is outline the situation briefly. Neither in my earlier letter nor in this one am I presenting any apologia for doctrinal belief, either scientific or philosophical. I am only clearing up errors of fact and sketching a position in outline (*11*). A good starting point is to consider what the non-Catholic scientist would have to investigate if he wished really to understand Catholicism.

Many scientists today are materialistic monists in metaphysics and positivists in epistemology. The first thing one has to be willing to do is to subject these conclusions to methodic doubt. If at the end of this preliminary investigation one is still convinced that these are valid positions, there is no use going any further. If, however, one comes to the conclusion that the universe is best explained metaphysically by a material and spiritual dualism and that true and certain knowledge can be obtained by other means in addition to the complex vaguely called the "scientific method," the really basic question is whether or not there exists an intelligent, supreme being.

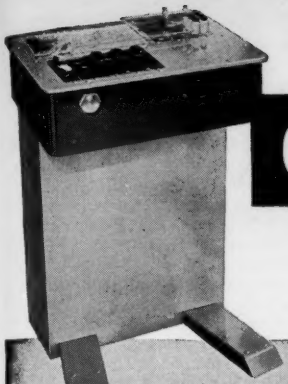
Careful, reflective thinking is necessary at this point. The few scraps of philosophical knowledge picked up in an education often markedly deficient in the liberal arts, and a materialist and positivist bias absorbed from teachers, will not be adequate and proper (*12*).

If one concludes that there is no God, he will remain a speculative atheist; if he concludes that we cannot know, he is an agnostic. However, if there does exist a supreme, personal, spiritual being, the second question is, has he ever had any formal, public contacts with the human race. Of all the literature on this subject only the books of the Old and New Testament can satisfactorily pass the required tests as valid historical documents. While an Orthodox Jew will reject the New Testament, he can certainly accept everything else up to this point.

The New Testament reveals a person who claimed, and proved himself to be, both God and man. Some Unitarians will drop out here, but most Christians will remain. It also shows that he founded a Church which cannot err in matters of faith or morals. Obviously most Protestants will not believe their church is infallible in faith and morals, although they will be able to accept the rest. However, if one is morally certain on the last five points, it is eminently rational to believe whatever such a church proposes for belief in the sphere in which it is competent.

When there is added to this the reasonable conclusion that truth in science cannot clash with truth in philosophy and theology, and vice versa, the problem of the supposed dualism as formulated by Calingaert and Rhodes simply does not arise. Apparent differences between science and theology are due to an incomplete understanding of the one or the other and will certainly be resolved on further study, though this, just as with purely scientific questions, may take years of effort. Theologians, being human, will occasionally make errors in scientific fields, as they did in the case of Galileo and Darwin. Scientists, at least as human, will make errors in the fields of philosophy and theology.

In my own experience, what has usually happened is that people who pride themselves on being very scientific will reject a priori, on what are actually philosophical, not scientific grounds, some religious belief. This is what Rhodes has done, in rather offensive terms, with respect to the doctrine of the Assumption (*13*). He is quite mistaken in saying that "scientist O'Loane is certain" on this point. *Scientist* O'Loane says nothing about this point for the reason that *science* says nothing pro or con. As I said earlier, it is a matter of an apostolic tradition,



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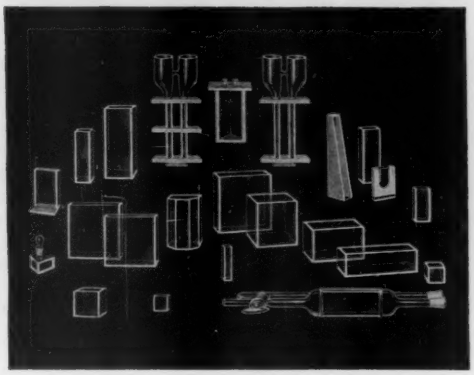

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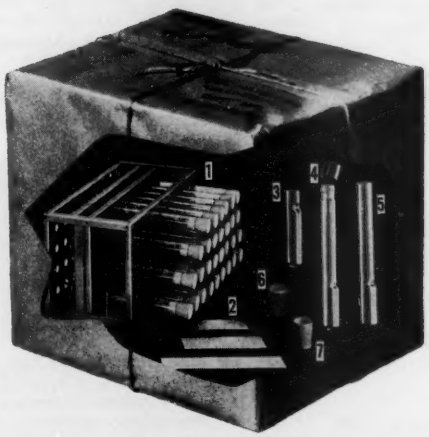

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which is morally certain and accepted both by Eastern Orthodox churches and by the Catholic Church.

There is *nothing* in Catholic doctrine which is contrary to any scientific fact, nor can there be any such in the future.

J. KENNETH O'LOANE
331 Seneca Parkway, Rochester, New York

References and Notes

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2. W. M. Agar, *Catholicism and the Progress of Science* (Macmillan, New York, 1940), pp. 32–40.
3. J. B. Conant, *On Understanding Science* (Yale Univ. Press, New Haven, Conn., 1947); *Science and Common Sense* (Yale Univ. Press, New Haven, Conn., 1951).
4. C. S. Slichter, *Am. Scientist* **31**, 168 (1943) (one of the fairer treatments by a non-Catholic mathematician).
5. P. F. Palmer, *Mary in the Documents of the Church* (Newman, Westminster, Md., 1952), pp. 59–61; quotation from St. John Damascene's sermon, "On the falling asleep of the Mother of God" (8th century).
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7. *Four Great Encyclicals* (Paulist Press, New York), p. 92. The paragraph referred to is the third following the quotation given by Hoffman.
8. J. M. O'Neill, *Catholicism and American Freedom* (Harper, New York, 1952), p. 160.
9. J. R. Connery, *America* **101**, 250, 252 (1959); D. J. Bradley, *Catholic World* **189**, 250 (1959).
10. Editorial, *The Commonweal* **60**, 333 (1954); A. M. Churchill, *ibid.*, **60**, 344 (1954); D. Lyons, *ibid.* **60**, 438 (1954); W. J. Grace, *Catholic World* **183**, 406 (1956); R. H. Amundson, *ibid.* **185**, 352 (1957).
11. Those who wish to know more of the reasons behind the Catholic Church's position on birth control may see J. L. Thomas, *Daedalus* **88**, 444 (1959); *Ave Maria* **91**, 5, 24 (1960); T. J. O'Donnell, *Morals in Medicine* (Newman, Westminster, Md., 1959).
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13. For the positions of various schools of Catholic thought on the condition of the body after resurrection, see George G. Smith (Ed.), *The Teaching of the Catholic Church* (Macmillan, New York, 1950), vol. 2, pp. 1232–1247.

The publication of these letters marks the end of a series of comments on M. E. Davis' review of A. W. Sulloway's book, Birth Control and Catholic Doctrine [Science **130**, *559 (1959)*].—ED.

Revolution by Committee?

Reading John W. Gardner's account of the life of Abraham Flexner [*Science* **131**, 594 (26 Feb. 1960)] I could not help but ask (as I'm sure many other readers asked): What would be the state of American medical education today had Pritchett appointed a *committee* to look into the matter 50 years ago?

GARRETT HARDIN
University of California (Santa Barbara), Goleta

Meetings

Clinical Scientists

The Association of Clinical Scientists, a recent affiliate of the AAAS, was organized in 1949 by a group of physicians and scientists working in various fields of laboratory medicine. During the early years the group held frequent informal meetings at the laboratories of its members and arranged a number of symposiums, workshops, and seminars on methodology in clinical chemistry which were held in the United States, Great Britain, and Puerto Rico. Until 1956, the association was called the Clinical Science Club. By 1956 the scope of activities of the Clinical Science Club had expanded, as had its membership, and it was then decided to incorporate the group as the Association of Clinical Scientists. The association received a charter from the state of Pennsylvania on 1 March 1957 as a nonprofit scientific organization. The objectives of the association, as outlined in the constitution, are as follows: (i) to promote education and research in clinical science by practical methods; (ii) to maintain and improve the accuracy of measurements in clinical laboratories and to promote uniformity in clinical laboratory procedures; (iii) to encourage cooperation between physician and nonphysician groups concerned with the application of scientific methods to medical practice; and (iv) to support the principles and ethics of the field of medicine and of its constituent basic sciences.

The association holds scientific meetings in the spring and fall. The spring meeting is held in either March or April and is devoted to the presentation of scientific papers by members and invited guests and to visiting clinical and research laboratories. The fall meeting is held in either October or November and is devoted to the presentation of an applied seminar in clinical science. In addition, informal dinner meetings of the association are held periodically in conjunction with international medical congresses and national scientific conventions.

ROBERT P. MACFATE
323 Northwood Road, Riverside, Illinois

Forthcoming Events

May

1–5. AAAS Southwestern and Rocky Mountain Div., Alpine, Tex. (M. G. Anderson, New Mexico College of Agriculture and Mechanical Arts, P.O. Box 97, University Park)

2. American Federation for Clinical Research, Atlantic City, N.J. (J. E. Bryan, 250 W. 57 St., New York 19)

2–3. Reactions between Complex Nuclei, 2nd conf., Gatlinburg, Tenn. (R. S. Livingston, Oak Ridge Natl. Laboratory, Oak Ridge, Tenn.)

2–4. Aeronautical Electronics, conf., Dayton, Ohio. (L. G. Cumming, IRE, 1 E. 79 St., New York 21)

2–5. Flight Test Symp., natl., San Diego, Calif. (H. S. Kindler, Instrument Soc. of America, 313 Sixth Ave., Pittsburgh 22)

2–11. International Cancer Cytology conf., Mexico, D.F., Mexico. (Office of Intern. Conferences, Department of State, Washington 25)

2–11. Pan American Medical Assoc., cong., Mexico City, Mexico. (J. J. Eller, 745 Fifth Ave., New York 22)

3–4. Association of American Physicians, Atlantic City, N.J. (P. B. Beeson, Yale Univ. School of Medicine, New Haven 11, Conn.)

3–4. Conference of Veterinarians, annual, Philadelphia, Pa. (W. H. Rhodes, School of Veterinary Medicine, Univ. of Pennsylvania, Philadelphia 4)

3–5. Society of Pediatric Research, Swampscott, Mass. (C. D. West, Children's Hospital, Cincinnati 29, Ohio)

3–6. Fuel Element Fabrication, symp., Vienna, Austria. (Intern. Atomic Energy Agency, 11 Kärntner Ring, Vienna)

5–6. American Pediatric Soc., annual, Swampscott, Mass. (A. C. McGuinness, 2800 Quebec St., NW, Washington 8)

5–8. Wilson Ornithological Soc., Gatlinburg, Tenn. (A. M. Bagg, Farm St., Dover, Mass.)

6–7. Minnesota Acad. of Science, St. Cloud. (J. P. Emanuel, Winona State College, Winona, Minn.)

6–7. North Carolina Acad. of Science, Greensboro. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

6–7. North Dakota Acad. of Science, annual, Fargo. (B. G. Gustafson, Box 573, University Station, Grand Forks, N.D.)

6–7. Population Assoc. of America, annual, Washington, D.C. (K. B. Mayer, Dept. or Sociology and Anthropology, Brown Univ., Providence 12, R.I.)

6–7. South Dakota Acad. of Science, 45th annual, Brookings. (J. M. Winter, Dept. of Botany, Univ. of South Dakota, Vermillion)

6–8. International Cong. of Phlebology, 1st, Chambéry, France. (J. Marmasse, 3, rue de la République, Orléans, France)

6–9. American Psychoanalytic Assoc., annual, Atlantic City, N.J. (Mrs. H. Fischer, 36 W. 44 St., New York 36)

7–8. Academy of Psychoanalysis, annual, Atlantic City, N.J. (M. Ross, American Psychiatric Assoc., 1700 18 St., NW, Washington 9)

9. American Acad. of Child Psychiatry, annual, Atlantic City, N.J. (M. Ross, American Psychiatric Assoc., 1700 18 St., NW, Washington 9)

9–10. American Soc. of Safety Engineers, Chicago, Ill. (A. C. Blackman, ASSE, 5 N. Wabash Ave., Chicago 2)

9–11. Aerospace Medical Assoc. 31st annual, Bal Harbour, Fla. (W. J. Kennard, AMA, Washington Natl. Airport, Washington 1)

9–11. Power Instrumentation, 3rd natl. symp., San Francisco, Calif. (H. S. Kindler, Instrument Soc. of America, 13 Sixth Ave., Pittsburgh 22, Pa.)

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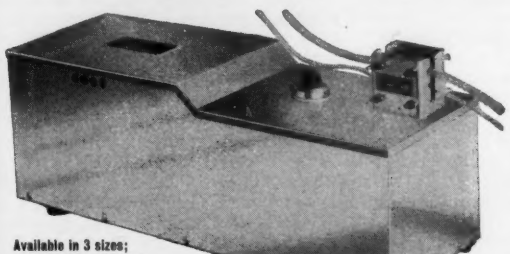

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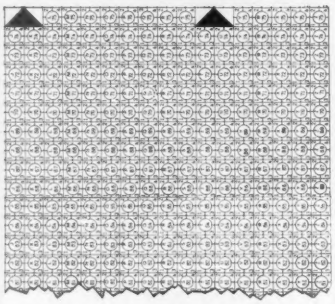

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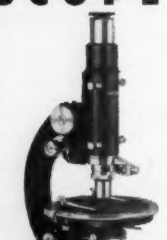

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9–11. Radiation Research Soc., 8th annual San Francisco, Calif. (E. L. Powers, RRS, Argonne Natl. Laboratory, Box 299, Lemont, Ill.)

9–12. American Rocket Soc. semi-annual, Los Angeles, Calif. (A. F. Denham, ARS, 925 Book Bldg., Detroit 26, Mich.)

9–12. Instrumentation Automation Conf. and Exhibit, summer, San Francisco, Calif. (Instrument Soc. of America, 313 Sixth Ave., Pittsburgh 22, Pa.)

9–13. American Psychiatric Assoc., annual, Atlantic City, N.J. (C. H. H. Branch, 156 Westminster Ave., Salt Lake City, Utah)

9–14. Fermentation, intern. symp., Rome, Italy. (Intern. Fermentation symp., Istituto Superiore di Sanita, Viale Regina Elena, 299, Rome, Italy)

10–12. Electronic Components, conf., Washington, D.C. (N. S. Hibsham, AIEE, 33 W. 39 St., New York 18)

10–12. Farm Electrification, conf., Omaha, Neb. (N. S. Hibsham, AIEE, 33 W. 39 St., New York 18)

10–12. Severe Storms, American Meteorological Conf., St. Louis, Mo. (K. C. Spengler, AMS, 45 Beacon St., Boston 8, Mass.)

10–13. Fuel Element Fabrication, symp., Vienna, Austria. (Intern. Atomic Energy Agency, 11 Kärntner Ring, Vienna)

11. Society of Medical Psychoanalysts, annual, New York, N.Y. (M. Ross, American Psychiatric Assoc., 1700 18 St., N.W., Washington 9)

11–13. American Assoc. of Genito-Urinary Surgeons, Dearborn, Mich. (W. J. Engel, 2020 E. 93 St., Cleveland 6, Ohio)

11–13. American Assoc. of Physical Anthropologists, Washington, D.C. (E. E. Hunt, Jr., Peabody Museum, Harvard Univ., Cambridge 38, Mass.)

11–13. American Assoc. for Thoracic Surgery, 40th annual, Miami Beach, Fla. (H. T. Langston, 7730 Carondelet Ave., St. Louis 5, Mo.)

11–13. American Inst. of Chemists, Minneapolis, Minn. (L. Van Doren, AIC, 60 E. 42 St., New York 17)

11–13. International Acetylene Assoc., annual, Seattle, Wash. (IAA, 30 W. 42 St., New York 17)

11–13. Quinones in Electron Transport, symp. (by invitation only), London, England. (G. E. W. Wolstenholme, Ciba Foundation, 41 Portland Pl., London, W.1)

11–13. Rare Earths in Biochemical and Medical Research, conf., Ames, Iowa. (J. G. Graca, College of Veterinary Medicine, Iowa State Univ., Ames)

11–14. American Helicopter Soc., annual, Miami Beach, Fla. (H. M. Lounsbury, AHS, 2 E. 64 St., New York 21)

11–14. National Science Fair-International, Indianapolis, Ind. (Science Service, 1719 N. St., Washington 6)

12. Protein and Amino Acid Supplementation, Chicago, Ill. [J. T. Sime (Assoc. of Vitamin Chemists), Evaporated Milk Assoc., 228 North La Salle St., Chicago 1]

12–14. American Assoc. for Cleft Palate Rehabilitation, Denver, Colo. (D. C. Spriestersbach, University Hospitals, Iowa City, Iowa)

12–14. American Inst. of Industrial Engineers, annual, Dallas, Tex. (F. J. Tittler, AIIE, 145 N. High St., Columbus 15, Ohio)

12–14. Virginia Acad. of Science, Richmond. (P. M. Patterson, Hollins College, Va.)

13–14. Proctological Latina, 2nd intern., Rome, Italy. (G. B. E. Simonetti, Via S. Raffaele 3, Milano, Italy)

15–18. American Soc. of Maxillo-facial Surgeons, Los Angeles, Calif. (E. C. Hinds, 1508 Medical Towers, Houston 25, Tex.)

15–18. International College of Surgeons, 12th biennial conf., Rome, Italy. (ICS, 1516 Lake Shore Drive, Chicago, Ill.)

15–20. American Water Works Assoc., annual conv., Miami Beach, Fla. (H. E. Jordan, AWWA, 2 Park Ave., New York 16)

15–19. Institute of Food Technologists, 20th annual, San Francisco, Calif. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3)

15–20. National Tuberculosis Assoc., Los Angeles, Calif. (J. C. Stone, 1790 Broadway, New York 19)

16–17. Society of American Military Engineers, natl. conv., Washington, D.C. (D. A. Sullivan, SAME, 140 S. Dearborn St., Chicago, Ill.)

16–18. American Opthalmological Soc., Colorado Springs, Colo. (M. C. Wheeler, 30 W. 59 St., New York 19)

16–18. American Trudeau Soc., Los Angeles, Calif. (F. W. Webster, 1790 Broadway, New York 19)

16–19. American Urological Assoc., Chicago, Ill. (W. P. Didusch, 1120 N. Charles St., Baltimore 1, Md.)

16–20. Medical Library Assoc., Kansas City, Mo. (Miss N. A. Mehne, Upjohn Co. Library, 301 Henrietta St., Kalamazoo, Mich.)

16–21. American Assoc. on Mental Deficiency, annual, Baltimore, Md. (N. A. Dayton, P.O Box 51, Mansfield Depot, Conn.)

17–18. Superconductive Technique for Computing Systems, symp., Washington, D.C. (Miss J. Leno, Code 430A, Office of Naval Research, Washington 25)

17–20. American Assoc. of Plastic Surgeons, Milwaukee, Wis. (T. D. Cronin, 6615 Travis St., Houston 25, Tex.)

18–19. Agricultural Meteorology, 3rd conf., Kansas City, Mo. (K. C. Spengler, American Meteorological Soc., 45 Beacon St., Boston, Mass.)

18–20. Society for Experimental Stress Analysis, spring, Indianapolis, Ind. (W. M. Murray, SESA, P.O. Box 168, Central Square Station, Cambridge 39, Mass.)

18–27. Wool Conf., intern., Harrogate, Yorkshire, England. (A. W. Bennett, Textile Inst., 10 Blackfriars St., Manchester 3, England)

21–22. Society for Economic Botany, 1st annual, Lafayette, Ind. (Q. Jones, New Crops Research Branch, Beltsville, Md.)

22. Maryland Acad. of Sciences, Baltimore. (J. W. Easter, Owings Mills, Md.)

22–26. Air Pollution Control Assoc., 53rd annual, Cincinnati, Ohio. (C. W. Gruber, 2400 Beekman St., Cincinnati 14)

22–26. Oil and Gas Power Conf., Kansas City, Mo. (D. B. MacDougall, ASME, 29 W. 39 St., New York 18)

(See issue of 18 March for comprehensive list)

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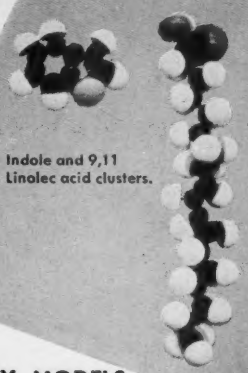

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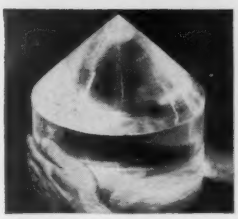

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The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ NONREACTIVE DECADE RESISTOR is said to be direct reading with accuracy of ±0.01 percent from d-c to at least 50 kcy/sec. Models are available with one to five dials for increments as small as 0.01 ohm and resistance values up to 100,000 ohm. Reactance compensation method permits choice of minimum inductance error, minimum reactance error, or best compromise. (British Industries Corp., Dept. Sci406, 80 Shore Rd., Port Washington, N.Y.)

■ SERVOMECHANISM BREADBOARDING SYSTEM is based on the provision of equally spaced gear centers established by pairs of accurately bored plates. The system uses gears whose pitch is a multiple of 24. Integral ratios of 1, 2, 3, 4, 5, 7, 8, 9 and 11 to 1 are possible, as well as a large number of nonintegral ratios. Completed units and stock components are illustrated in a 12-page catalog. (Gap Instrument Corp., Dept. Sci475, 116 Merrick Rd., Freeport, N.Y.)

■ ALTERNATING CURRENT METER is an a-c/d-c comparator for measurement of current, voltage, and power at frequencies up to 1000 cy/sec. Accuracy is said to be ±0.05 percent. Current range is 125 amp with extension to 500 amp provided by an accessory transformer. Voltage range is up to 600, extendable to 1500. Power range is 100 amp and 600 volts. The instrument is direct reading to 0.1 percent. (Physics Research Laboratories, Inc., Dept. Sci468, P.O. Box 555, Hempstead, N.Y.)

■ PEAK VOLTMETER measures peak or peak-to-peak values of repetitive waveforms. The d-c component is not measured. Frequency range for sine waves is 5 cy to 500 kcy/sec, but distorted waveforms with harmonics extending up to 2 Mcy/sec can also be measured. Pulses with duration from 0.5 μsec to 5 msec and with repetition rate to 500,000/per second can also be measured. Accuracy ranges from ±2 percent to ±5 percent, depending on the waveform measured. The instrument is useful also as a wide-band amplifier with gain of 86 db and source impedance approximately 3 ohm in series with 0.22 μf. Maximum output is 150 volts peak-to-peak. (Ballantine Laboratories, Dept. Sci484, Boonton, N.J.)

■ DIODE BOX is a decade type substitution box with a selector switch that enables interchange of any one of eleven 10-watt silicon-type Zener diodes covering the voltage range from 3.6 to 30. (International Rectifier Corp., Dept. Sci471, 1521 E. Grand Ave., El Segundo, Calif.)

■ THERMOELECTRIC GENERATOR ELEMENTS of lead telluride are available for experimental applications in six standard sizes with positive types designated TEG2P and negative type TEG2N. Hot-junction surfaces are prefinished, and cold-junction surfaces are pretinned. Over-all efficiencies of 6 percent are reported. (Minnesota Mining and Manufacturing Co., Dept. Sci411, 900 Bush Ave., St. Paul 6, Minn.)

■ PULSE-HEIGHT ANALYZER is a five-channel differential analyzer designed to accept balanced or single-ended pulses of rise time and duration in the range 0.1 to 10 msec, as encountered, for example, in the observation of the passage of action potentials down nerve fibers. Sorted pulses are counted by glow-transfer scalers and mechanical registers. Total capacity per channel is 99,999, and maximum average counting rate in each is 150 pulses per second. A nonoverloading internal preamplifier of continuously adjustable gain between 0.1 and 1000 is provided. A preselected portion of the pulse-height spectrum may be further expanded by a factor up to five. The basic range of the analyzer proper is 10 to 70 volts peak. (Elex, Dept. Sci473, 1417 Slaterville Rd., Ithaca, N.Y.)

■ ANALOG-COMPUTER CONTROL SYSTEM employs a control unit composed of operational magnetic amplifiers and passive network elements. Analog signals received from transducers are subjected to the mathematical operations of addition, subtraction, ratioing, integration, differentiation, and mutiplication. The output signal is then used to adjust final control elements to act on the process function under control. (Hagan Chemicals and Controls Inc., Dept. Sci477, Hagan Building, Pittsburgh 30, Pa.)

■ CABLE TESTER is designed to prove cables and fixtures without destruction. A typical model tests five cables from 3 to 10 ft long simultaneously. Load is hydraulically applied, up to a maximum of 2000 lb, and is maintained for a preset period. Breakage of a defective cable does not overstress any of the others. (Steel City Testing Machines, Inc., Dept. Sci476, 8817 Lyndon Ave., Detroit 30, Mich.)

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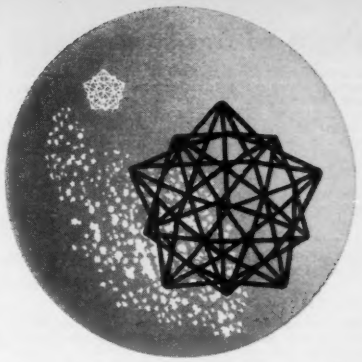

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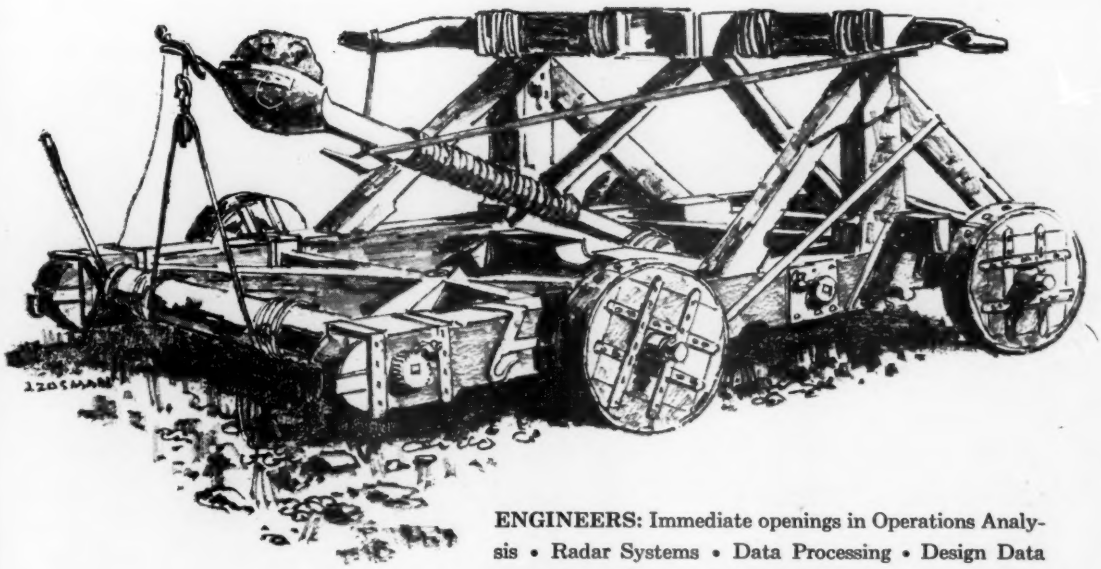

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